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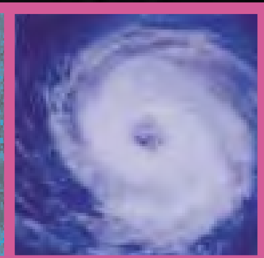



20 Years of Conceiving Ideas and Realizing Achievements

Colorado State University

CIRA

Fellowships in Atmospheric Science and Related Research

The Cooperative Institute for Research in the Atmosphere at Colorado State University (CIRA) offers a limited number of one-year Associate Fellowships to research scientists. Awards may be made to senior scientists including those on sabbatical leave or recent Ph.D. recipients. Those receiving the awards will pursue their own research programs, collaborate with existing programs, and participate in Institute seminars and functions. Selection is based on the likelihood of an active exchange of ideas between the Fellows, the National Oceanic and Atmospheric Administration, Colorado State University, and CIRA scientists. Salary is negotiable based on experience, qualifications, and funding support. The program is open to scientists of all countries. Submitted applications should include a curriculum vitae, publications list, brief outline of the intended research, a statement of estimated research support needs, and names and addresses of three professional references.

CIRA is jointly sponsored by Colorado State University and the National Oceanic and Atmospheric Administration. Colorado State University is an equal opportunity employer and complies with all Federal and Colorado State laws, regulations, and executive orders regarding affirmative action requirements. In order to assist Colorado State University in meeting its affirmative action responsibilities, ethnic minorities, women, and other protected class members are encouraged to apply and to so identify themselves. The office of Equal Opportunity is in Room 101, Student Services Building. Senior scientists and qualified scientists from foreign countries are encouraged to apply and to combine the CIRA stipend with support they receive from other sources. Applications for positions which begin January 1 are accepted until the prior October 31 and should be sent to: Prof. Thomas H. Vonder Haar, Director CIRA, Colorado State University, Fort Collins, CO 80523, USA. Research Fellowships are available in the areas of: Air Quality, Cloud Physics, Mesoscale Studies and Forecasting, Satellite Applications, Climate Studies, Model Evaluation, Economic and Societal Aspects of Weather and Climate.

For more information, contact www.cira.colostate.edu

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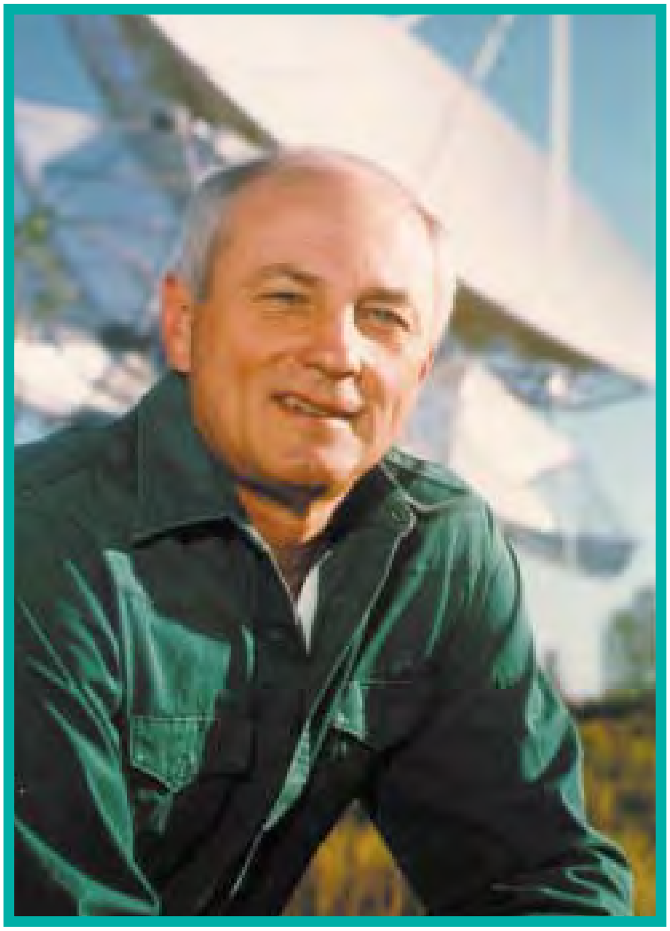

CIRA is on a remarkable science journey. It began in 1980 with the realization that complex questions in weather, climate, and related disciplines required a multidisciplinary team approach. Addressing the science challenges also required a multi-faceted research infrastructure rarely found in a single group.

Scientists and engineers on CIRA research projects are discovering new knowledge not only about *what* is happening in the atmosphere but *why* it happens. Applying the new information to improve weather forecasting and to other areas of weather and climate applications is a theme throughout our research. We are a force in both national and international efforts to understand global and regional climate variations. Our staff endeavors to move our discoveries into practice and application via an active program of technical transfer, outreach, education, and training.

As we renew and redirect our research collaborations with federal sponsors during our 20th year, the opportunity for incorporating new ideas and approaches is with us again. I am confident that CIRA's science during its next two decades will be as exciting and productive as it has been during the first 20 years.

Tom Vonder Haar
Director of CIRA and University Distinguished Professor of Atmospheric Science

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Synopsis of CIRA's Early Activities and Highlights of its Principal Achievements during the Past 20 Years

Cliff Matsumoto, Associate Director

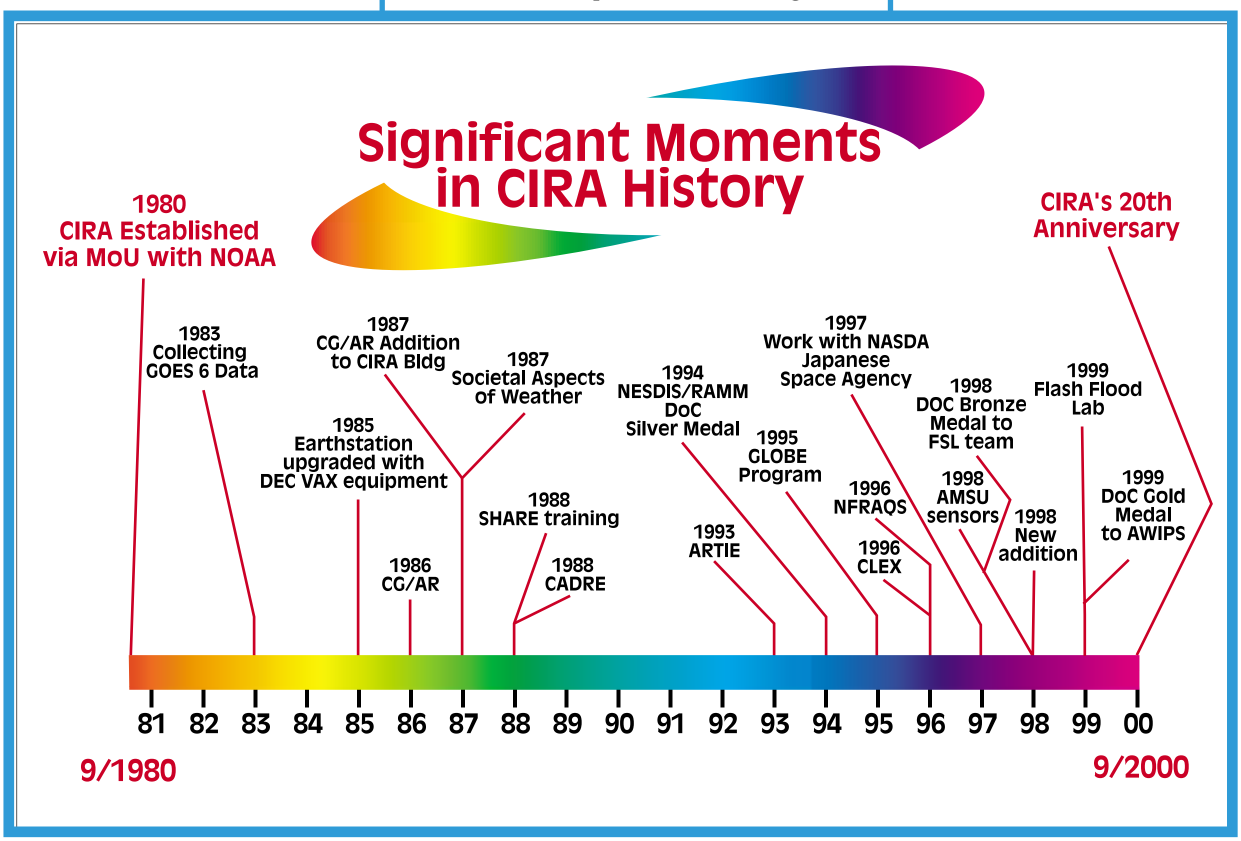
The Cooperative Institute for Research in the Atmosphere (CIRA) was formed in 1980 between CSU and the National Oceanic and Atmospheric Administration (NOAA) to increase the effectiveness of atmospheric research of mutual interest to NOAA, CSU, the State, and the Nation. Tom Vonder Haar, then Head of the Atmospheric Science Department, made the arrangements in collaboration with CSU faculty in several disciplines along with Joe Fletcher of NOAA-ERL and David Johnson and Harold Yates of NOAA/NESS. CIRA is the seventh cooperative institute established by NOAA following those at CU, Miami, Hawaii, Washington, Oklahoma, and Wisconsin, and the first without a large pre-existing NOAA laboratory on site. Initial research program elements included collaborations with NOAA by professors and students from the university departments of Atmospheric Science, Electrical Engineering, Economics, and Statistics.

Initial participation by NOAA was through the Environmental Research Laboratories and the National Earth Satellite Service (NESS). Five research scientists from NOAA/NESS arrived on campus shortly following CIRA's establishment as the first visible commitment to the budding partnership. The basic objective of the joint effort between CSU and NESS was to develop uses of meteorological satellite data for research purposes and environmental applications. The support of the NOAA/ERL Prototype Regional Observing and Forecasting Service (PROFS) initiative was also the focus for research collaboration through development of nowcast products, the integration of satellite data and products for the PROFS Experimental Data Facility, the evaluation of those products and data used in support of PROFS, and the training of PROFS personnel in the uses of satellite data and products.

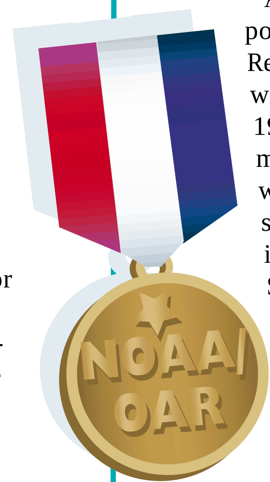
Research Themes and Research Teams

As its initial research themes, the Institute addressed global climate dynamics, local area weather forecasting, weather modification, and the application to meteorological field programs of a new atmospheric sounder system aboard NOAA's latest (at that time) environmental monitoring satellite: GOES-4.

The ranks of CIRA's Fellows were initially comprised of Ron Alberty (NOAA/ERL), Don Beran (NOAA/ERL), Glen Brier (CSU/Atmos), Tom Brubaker



(CSU/EE), Hal Cochrane (CSU/Economics), Lou Grant (CSU/Atmos), Tom McKee (CSU/Atmos), Paul Mielke (CSU/Statistics), Jim Purdom (NOAA/NESS/RAMM), and Pete Sinclair (CSU/Atmos). With contributions from its initial cadre of Research Associates – Neil Allen (CSU/Atmos), J. Goggin (CSU/Atmos), Bob Green (NOAA/NESS/RAMM), Melanie Kruidenier (CSU/Atmos), Bob Lipschutz (NOAA/ERL), Roger Phillips (NOAA/NESS), Ron Wachtmand (CSU/Atmos), John Weaver (NOAA/NESS/RAMM), Herb Winston (NOAA/ERL), Garrett Campbell (CIRA), Don Hillger (CIRA), and Ray Zehr (NOAA/NESS/RAMM) – five major cooperative research activities involving a cross-exchange of personnel and research facilities were underway during the early years. Climate Research, Weather Modification Research, Mesoscale Studies (PROFS and SESAME), VAS (VISSR Atmospheric Sounder) Evaluation Program, and Radiation-Cloud-Aerosol Program were the broadly defined research areas under which specific projects such as "Assessing On-going Operation Cloud Seeding Program," "Pilot Studies for the International Satellite Cloud Climatology Project," "Estimating the Uses and Benefits Derived from PROFS," and "Development of a Daytime Multispectral Radiative Signature Technique for Estimation of Rainfall from Satellites" were actively pursued.



Several long-enduring efforts are synonymous with CIRA. One of them that CIRA has been associated with since its inception is the International Satellite Cloud Climatology Project (ISCCP). As part of the WMO project to collect and process satellite data to produce global estimates of cloud properties, CIRA began collecting GOES-6 data in July 1983 (See details in ISCCP article in this issue).

Air quality was added as a new research theme in 1983 and addressed through an alliance with NOAA and the National Park Service. One aspect of this research area was an investigation of how people perceive and react to changes in visibility. This required expertise in atmospheric science, applied physics, statistics, recreation science, and psychology (See details elsewhere in this issue).

1985 marked a major expansion of CIRA's weather satellite Earthstation data collection system. Since 1977, the CSU Departments of Atmospheric Science and Electrical Engineering had managed one of only three full-resolution satellite earth-stations in the U.S. at that time. In September 1985, the earthstation's computer equipment was upgraded with DEC VAX equipment. (See details elsewhere in this issue).

A Center for Geosciences supported by the U.S. Army Research Office was established within CIRA in September 1986. The award of approximately $11.5M over five years was shared among at least seven CSU departments including Atmospheric Science, Civil Engineering, Electrical Engineering, Earth Resources, Psychology, Physics, and Mathematics. Initially housed in a building at the University's Solar Village, an addition to the CIRA building was completed in May 1987 to support the Center's research activities. Atmospheric and surface remote and in-situ sensing; atmospheric modeling of meteorological parameters and dispersion; hydrologic modeling; and geoscience information extraction were among the research areas addressed (See details elsewhere in this issue).

Economic and societal aspects of weather and climate were incorporated into CIRA's research theme in FY 1987. Collaborations in this area culminated with the selection of CIRA's Chris Adams as the recipient of the 1996 NWS Modernization Award. He had led the efforts to incorporate social science research on individual and community hazards warning response into NWS operations.

Interdisciplinary research in the area of atmospheric-biosphere interactions via collaboration with the Natural Resource Ecology Lab (NREL) took on special emphasis in 1988 with a proposal submission to the NSF (National Science Foundation) on establishing a Center for the Analysis of the Dynamics of Regional Ecosystems (CADRE). The purpose of the Center was to foster a multi-institutional and trans-disciplinary center of excellence in science and technology, to better understand the atmospheric processes responsible for, and the ecological consequences of, global climate change, and to evaluate the viability of alternate strategies for dealing with these problems. Initial focus was on the Great Plains of North America. Professor Roger Pielke of Atmospheric Science was one of the CADRE leaders and continues this collaboration.

The SHARE (Software Help in Applications, Research, and Education) program initiated in 1987 is a cooperative effort with the WMO to develop analysis and display software for meteorological data. The international project emphasizes a "package" concept, which includes computer hardware specifications, user-friendly software, and training. In addition to developing data handling and display programs for SHARE, CIRA hosted a 2-week session for SHARE team members – the first time that an international group had been trained in the U.S. under this program – in September 1988.

Continued Growth in the 90s

The Applied Research and Technology Interchange Effort (ARTIE) established a formal working arrangement between CIRA's NOAA/NESDIS RAMM branch and the NWS Forecast Office in Cheyenne, WY for the two-way transfer of ideas, research, and technology in 1993. As an example of cooperative efforts between research and operations, a computer-based expert system for severe storm forecasting was developed and field-tested at the Cheyenne WSFO.

Significant modifications were made to CIRA's ingest hardware and software to accommodate the new data transmission format called GOES VARiable (GVAR) that occurred with the launch of GOES-I in 1994.

1994 also witnessed the Silver Medal award granted by the Department of Commerce to the NESDIS/RAMM team for its contribution to the implementation of systems and science support of the GOES-NEXT satellite program. The RAMSDIS team also received a special Letter of Commendation from the Director of NWS complimenting them on the value-added nature of the 60 RAMSDIS satellite product display workstations deployed in NWS Forecast Offices (See details in RAMSDIS article in this issue).

In February 1994, CIRA changed affiliation from the Graduate School to the

College of Engineering as part of a CSU reorganization plan.

On Earth Day 1995, the Global Learning and Observations to Benefit the Environment (GLOBE) program was initiated at FSL. From modest beginnings, the program has expanded to over 9500 schools in 92 countries. GLOBE K-12 students conduct measurements in the areas of Atmosphere, Hydrology, Soil, Land Cover, and Biology investigations. The CIRA staff at FSL develop and maintain the main GLOBE web server, the real-time acquisition, and the central GLOBE database.

In 1996, many CIRA collaborators were involved in FSL's extensive support of the Summer Olympics in Atlanta. The local NWS Forecast Office was augmented with the installation of LAPS (Local Analysis and Prediction System) and the running of a 2-km grid RAMS forecast model. LAPS and an MM90 version of the MM5 forecast model were also installed at the USAF Global Weather Center.

The Northern Front Range Air Quality Study (NFRAQS), a $2.5M project sponsored by government, industry, and trade groups, was initiated by CSU in 1996. The study was designed to address three policy-driven objectives: 1) identify the sources of airborne carbonaceous particles; 2) understand the relative importance of ammonia, nitrogen oxide, and sulfur dioxide emissions in formation of secondary particles; and 3) perform source apportionment of ammonium nitrate and ammonium sulfate aerosols along the Northern Front Range (See information on CIRA's air pollution research).

1996 was also the first in a series of Cloud Layer Experiments (CLEX) funded by the DOD Center for Geosciences. CLEX is a field program designed to collect observational data to support research into the morphology and behavior of Complex Layered Clouds. Aircraft in-situ measurements of cloud properties along with airborne cloud radar images were compared to remotely sensed algorithms for cloud liquid water and water vapor.

In 1997, CIRA began participation in research activities with the National Space Development Agency of Japan (NASDA) with sensor data aboard their Advanced Earth Observing Satellite (ADEOS). The effort involved work with two instruments – the Global Imager, a 36-channel optical sensor used for studying the biomass over land and ocean, and the properties of clouds, aerosols, water vapor, and land surfaces; and the Advanced Microwave Scanning Radiometer (AMSR), a 14-channel microwave sensor used for gathering information about cloud liquid water, water vapor, rainfall and surface properties to better understand the global water cycle.

With the launch of NOAA-15 in 1998, CIRA began developing products from its Advanced Microwave Sounding Unit (AMSU) sensors. Working closely with its NESDIS/RAMM team, products such as total precipitable water, instantaneous rain rate, cloud liquid water, and snow cover are available interactively and in real-time.

In mid-1998, CIRA took occupancy of a new wing that was added to its facility. A new teleconferencing capability was intended to help implement several virtual laboratory concepts like the VISIT program and the Flash Flood Laboratory.

1998 witnessed the awarding of the Department of Commerce Bronze Medal to the FSL team comprised partly of CIRA researchers responsible for development of the Rapid Update Cycle, Version 2 (RUC-2), an hourly analysis and prediction system, and its implementation into operations at NCEP (National Centers For Invironmental Prediction).

In 1999, the DEC VAX and PDP mini-frames installed in 1985 to perform satellite data collection tasks were replaced by a new Windows NT platform. Archived (2 months) GOES, AVHRR, and Meteosat images are available for display via the CIRA web page.

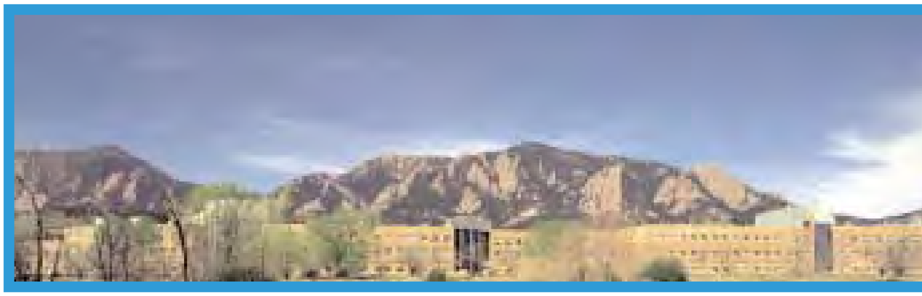
In 1999, CIRA established the CSU Flash Flood Laboratory to provide the opportunity for a wide range of academic disciplines including atmospheric science, hydrology, geology, geography, sociology, public administration, economics, and natural resources to collectively address flash flooding in an end-to-end process.

1999 also culminated with the awarding of the Department of Commerce Gold Medal to the AWIPS development team. All of the CIRA team members were recognized with CIRA Certificates of Recognition while key technical leaders were awarded the CIRA Research Initiative Award. The development of AWIPS also earned the project the 1999 ComputerWorld Smithsonian Laureate Award for best and most innovative technology in the "Environment, Energy, and Agriculture" category.

From its inception, CIRA has hosted annual conferences and workshops.

- In 1984, a conference entitled "Workshop on Agricultural and Forest Meteorology" attracted participants from Yale, NOAA/ERL, NOAA/NESDIS, and various CSU departments including Atmospheric Science, Agricultural and Chemical Engineering, Electrical Engineering, Forest and Wood Science, USDA Crops Research Lab, and Plant Pathology.
- In 1985, CIRA hosted the WMO Cloud Top Boundary Layer Conference on the main campus of CSU.
- In 1986, a workshop entitled "Acid Deposition in Colorado – A Potential or Current Problem; Local Versus Long-Distance Transport into the State" was held with attendees from across the Nation and Canada concerning applications of atmospheric sciences to acid deposition.
- In 1987, CIRA hosted a meeting of the International Satellite Cloud Climatology Project (ISCCP) attended by representatives from several countries to help form the policies on which the ISCCP operates.
- In 1987, CIRA hosted a workshop entitled "Monitoring Climate for the Effect of Increasing Greenhouse Gas Concentrations." Invited participants included many prominent modelers and observational scientists.
- In 1993, CIRA co-sponsored a GEWEX Global Water Vapor Project (GVaP) workshop with NOAA and the World Climate Research Programme. Attendees included 40 scientists from across the U.S. and other nations.

NOAA Collaborations–The Early Years



Cliff Matsumoto, Associate Director

. . . Segments were excerpted from the weekly PROFS Notes and PROFS Annual Reports.

The establishment of CIRA in September 1980 formalized research collaborations between Colorado State University and the NOAA Environmental Research Laboratories in Boulder. One of the major objectives of the embryonic partnership was support for the Prototype Regional Observing and Forecast Service (PROFS) in Boulder. Specific areas of investigation included assistance with satellite data collection, integration of satellite data and products for the PROFS experimental data facility, the development of nowcast products, societal aspects of severe weather warnings, estimated uses and benefits derived from these products, and the training of PROFS personnel in the uses of satellite data and products. A memo issued in November 1981 by the PROFS-CSU steering committee outlined specific aspects of collaboration between the two groups, principally in the area of satellite data collection. A new system to receive and transmit satellite data from CSU to PROFS was installed while PROFS built its own direct readout ground station. CSU also played a vital support role in a series of real-time exercises conducted by PROFS to evaluate overall system capability and performance to deliver data and products to their workstations.

Mesonet and Other Nowcasting Breakthroughs

PROFS' first 4-year phase was dedicated to building a "nowcasting" capability. The approach was to develop a system to acquire, process, and display the data necessary to study weather events in a real-time operational work environment. In addition to the satellite data collection efforts, real-time radar data acquisition, processing, and display techniques were explored by PROFS, including applications to derive Constant Altitude Plan Position Indicator (CAPPI) images and echo tops maps from volumetric WSR-74C radar data. Algorithms that were later implemented in the NEXt generation RADar (NEXRAD) Doppler radar system were coded and evaluated prior to handoff to the bidding NEXRAD contractors.

Another key technology for mesoscale nowcasting explored by PROFS was the real-time surface Mesonet, which comprised a 22-station network in northeastern Colorado (see accompanying map depicting the PROFS surface mesonetwork stations). CIRA support included an interactive time series plotting capability and a thorough data quality assessment effort.

An initial evaluation of this capability occurred during the summer of 1982 with its first real-time forecast exercise meant to evaluate the PROFS real-time operational workstation as an aid to improving the timeliness and accuracy of short-term forecasts. Results suggested that improved forecasting performance was possible with the advent of advanced technology and training of forecasters in preparing short-term forecasts. After concentrating its first 4 years on several convective season real-time forecast exercises, PROFS conducted its first cool-season forecasting experiment during the winter of 1984.

Phase Two: New Challenges

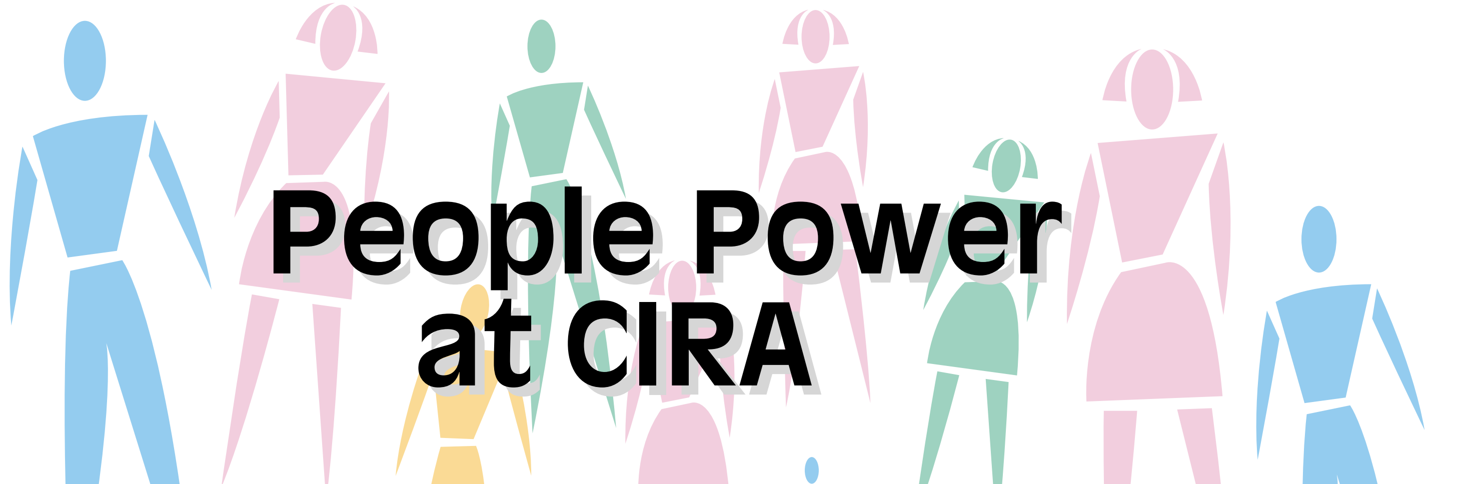
Looking ahead into its second 4-year phase, the January 1984 PROFS Program Review restated the Phase I goals, showed how they had been fulfilled, and defined the goals for Phase II. Emphasis during the Review was on continued commitment to the improved forecast goal – wrapped around AWIPS-90, planned ingest of VAS data, and work on NEXRAD algorithms, software, and applications programs. Collaboration with the Profiler group at the ERL (Environmental Research Laboratories). Wave Propagation Lab on a joint data retrieval project was also mentioned. In concert with these goals, PROFS underwent an organizational change with the formation of two new branches in FY 85. A portion of the Science Branch of the Exploratory Development Group was detached to form the separate Analysis and Prediction Branch, dedicated to the development of a Mesoscale Analysis and Prediction System (forerunner to the current Rapid Update Cycle model) and the support of the Federal Aviation Administration's (FAA's) Central Weather Processor program. The new Experimental Forecast Systems Branch was formed to concentrate on the development of products and applications for the PROFS advanced forecasting workstation (forerunner of the WFO-Advanced and AWIPS project). During 1985, efforts of all six branches of PROFS were focused on their real-time summer forecasting exercise. An important occurrence during the exercise was the Cheyenne flood of August 1. Exercise forecasters were able to better predict the severity of the storm with the help of the PROFS workstation and advanced data sets.

The Folks Behind the Science

Early leaders of PROFS such as Don Beran, Ron Alberty, and Sandy MacDonald have served as CIRA Fellows over the years. The CIRA pioneers in Boulder were Dan Birkenheuer, Bob Lipschutz, and Herb Winston. Dan left CIRA in 1999, but during his nearly 20-year tenure, he supported the early efforts to archive forecasts and verification data to assess forecaster performance. Statistics were key in determining the display products and temporal data resolution necessary to maximize the cost-to-benefit ratio of the PROFS prototype system. Dan also worked to incorporate VAS satellite data into the PROFS Operational Workstation. Bob Lipschutz (Aug 1981) developed a variety of data handling systems including a Doppler radar capability to support NEXRAD algorithm testing which ultimately led to some of the techniques found in the current AWIPS system. Herb Winston was also involved in the development of radar algorithms and the data transfer and ingest of VAS data. In addition, Kevin Brundage (May 1982) spent time with the Workstation Team and finally settled into the MAPS group.

John Weaver and Ray Zehr representing CIRA/NESDIS participated in the very first PROFS '82 real-time exercise, joined by Ed Szoke from NCAR and others in later exercises. Glenda Wahl (June 1983), Ron Kahn (Aug 1983), Mike Biere (Nov 1983), Tracy Smith (Jan 1984), Jim Ramer (Jan 1984), Joanne Edwards (Mar 1984), Renate Brummer (1983/85 as Ph.D. student; 1986), Greg Pratt (1985), Mary Sue Schultz (1985), Steve Albers (1986), Pete Stamus (1986), and Tom Kent (1987) were other "contract" personnel who matured with PROFS and eventually joined CIRA over the years.

The ranks of CIRA staff members in Boulder – primarily at FSL – steadily grew starting in the early '90s. Numbering approximately 20 in 1993, the staff doubled in size during FY94/95. By FY 96/97, CIRA's presence in Boulder peaked near 70 members. CIRA personnel now populate six of the seven Lab divisions. They are an integral part of virtually all major projects at FSL – from data assimilation and mesoscale model development to high performance computing and 3D visualization. They form the core of the development effort for the internationally acclaimed GLOBE program and the NWS award-winning AWIPS program. They provide cutting-edge technological expertise in wavelet transform techniques for satellite image compression and dissemination as well as gridded model output fields over the Internet. They are vital to the development and maintenance of real-time meteorological data acquisition and processing systems within the FSL Central Facility. CIRA personnel also contribute to research efforts within NOAA's Environmental Technology Lab and the NESDIS National Geophysical Data Center. The CIRA homepage provides a link (http://www.cira.colostate.edu/collaborative/collresrearch.htm) to a description of all the current, and ongoing research efforts involving CIRA members in Boulder.



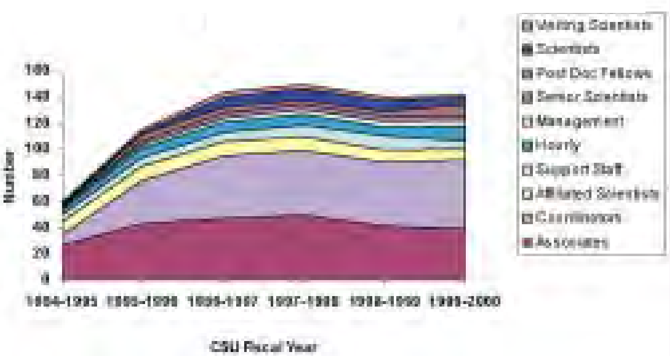
People Power at CIRA

Mary McInnis, Technical Editor

An organization is only as strong as the people who work behind the scenes. Although the phrase is somewhat clichéd, its truth is in evidence every day here at CIRA. The reputation for excellence that has been established over the years has much to do with the caliber of people who have worked, or are continuing to work, in this facility. Thus, in the spirit of this 20th anniversary issue, we'd like to take a moment to shine the proverbial spotlight on the people who have contributed to our organization's success.

One of the most revealing statistics concerning growth at CIRA is illustrated in the chart below. Figures compiled from 1994 to 2000 demonstrate how staff levels in all sectors of employment have increased steadily over the years. This chart also serves as evidence of the successful track record of CIRA proposals and research activities insofar as additional scientists and support staff were needed to carry out the work.

CIRA Personnel/Affiliations



Another distinguishing feature of CIRA employees is the variety of academic backgrounds from which they hail. Perhaps one of the greatest strengths of the Institute is its multidisciplinary perspective on areas of inquiry. A sampling of the advanced degrees held by CIRA personnel includes Sociology, Electrical Engineering, Computer Science, Atmospheric Science, and French. As is reflected in CIRA's mission statement, our affiliation with the university strengthens our operation by allowing us to draw on any number of academic departments to enhance our capabilities. As is evident from the list above, the mission carries through to individual employees as well.

In regard to CIRA's affiliation with Colorado State University, mention also needs to be made of another important group of people who have contributed to CIRA research. Graduate students have had a constant presence at CIRA since its inception. Whether under the guidance of Dr. Vonder Haar directly, or as students of Atmospheric Science in general, the graduate student contribution has been significant. In fact, many former students have elected to stay on board upon completion of their degrees, and have thus had an even wider range of experience with the Institute. In any event, student involvement with CIRA has been, and will continue to be, a fruitful learning experience for both their mentors and themselves.

A further testament to the quality of individuals who work at CIRA is the loyalty which so many have shown to the institute. Those who share membership in the club of employees with over ten years of service are numerous. In anticipation of this special edition, we solicited comments from a number of "10-plus" folks for their thoughts on how things have changed and what working here has meant to them (See facing page).

In closing, we'd like to pay recognition to all of the employees who have been aboard for at least 5 years:

More Than 15 Years: Joanne DiVico / Roger Pielke / Loretta Wilson / Tom Vonder Haar

11-15 Years: Chris Adams / Steve Albers / Garrett Campbell / Kelly Dean / Mike Hiatt / Adrian Marroquin / Nan McClurg / Lance Noble / James Ramer / Don Reinke / Jim Sisler / Tracy Smith / Duane Whitcomb / Julie Winchester

5-10 Years: Jerry Browning / Renate Brummer / Kevin Brundage / Young Chun / Cindy Combs / Randall Collander / Bernie Connell / Scott Copeland / Jack Dostal / Thomas Dotts / Ken Eis / John Forsythe / Jim Frimel / Shelby Frisch / Kathy Fryer / Yahya Golestani / Hiroyuki Gosden / Tom Greenwald / Bob Hufzinger / Brian Jamison / Ron Kahn / Stan Kidder / Chris King / Jeff Lemke / Chungu Lu / Philip McDonald / Sean Madine / Jay Paschall / Francis Tower / Ning Wang / Dave Watson / Marilyn Watson / Yuanfu Xie

Mike Hiatt, 13 years of service

Ive been here twelve years. In that time I have experienced significant technology changes that dramatically improved how each of us get our work or science done.

Don Beran, currently with NOAA in Boulder, Colorado

My association with CIRA started some 20 years ago when the Institute was being formed. At the time I directed the PROFS program which was housed in NOAAs Environmental Research Laboratories. There was a close collaboration between CIRA and the newly formed PROFS program, on the development of real-time satellite display systems for Denver-based NWS forecasters. I later served several years on the CIRA council, where I recall many stimulating discussions with Tom Vonder Haar and Jim Purdom on the future direction of the Institute. As an alumnus of CSU, I appreciated the opportunity to visit the Atmospheric Science Department on my trips to attend the Council meetings.

Chris Adams, 11 years of service

It has been a personally and professionally rewarding time. My work on the social and economic impacts of weather has been encouraged and supported by my colleagues from atmospheric science and other geophysical sciences. The intellectual excitement and wondering that goes on here is truly a unique environment. The fact that Ken Eis can come up with the idea for a multidisciplinary Flash Flood Laboratory, and under the auspices of CIRA get it approved by the University, is a bold step into the future of scientific research. Being a part of CIRA and CSU has provided instant scientific credibility in many research settings. As Tom keeps reminding me, this is serious science, but we should have fun. ... and we do both.

Joanne DiVico, 18 years of service

It is really amazing to see how CIRA has come from such humble beginnings one of NOAA s best (if not the best) joint institutes.

I have worked as the Director s Assistant since the mid-1980s and anticipate that is the position I will retain until that fateful retirement date. I have seen many come and go and many maintain through the years. I think CIRA has a great group of people that work together extremely well. All in all, its been a pleasure.

Duane Whitcomb, 11 years of service

It s really been enjoyable for me to see how the proliferation of computing and visualization resources has changed the entire way CIRA does business.

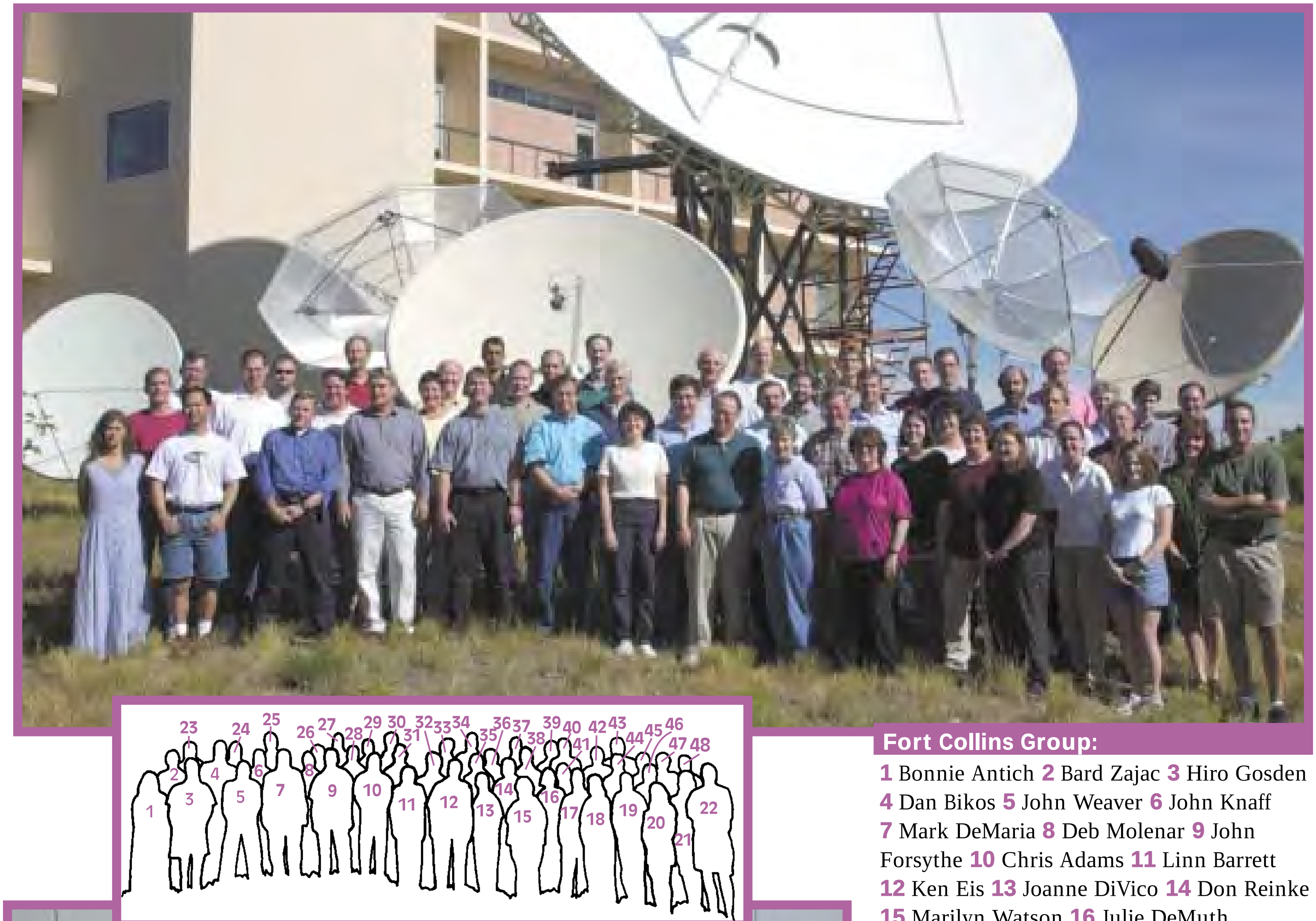
John Forsythe, 6 years of service

I think CIRA provides an excellent atmosphere to study, well, the atmosphere! Our computer and data resources are top-notch. All of the people at CIRA do high-quality work; it s fun to be part of the team. We routinely do things at CIRA that amaze similar research institutes. I am very proud to say I work at CIRA.

Kevin Schrab, currently with the National Weather Service in Denver, Colorado

I was only at CIRA for a short time from 1993 until 1995, but I genuinely enjoyed my time there. The interactions with the people at CIRA made my short stay there one of the best experiences of my professional life. I worked on the RAMMT on the development of RAMSDIS. Key members working on the RAMSDIS effort included Debra Molenar, Hiro Gosden, and Patrick Dills. Interacting with these people was very enjoyable. My CIRA experience also allowed me to have great contacts with NWS Forecast offices. This interaction actually led to my leaving CIRA, as the NWS Western Region recruited me to work on satellite projects in their Scientific Services Division.

I see CIRA s future as being very bright. The associations that CIRA has with other agencies continue to grow and mature. I believe these interactions will continue to contribute to our understanding of the atmosphere and improve our forecasting of the weather.



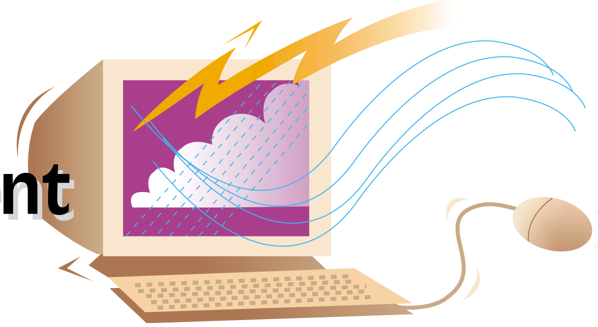
Fort Collins Group:

1 Bonnie Antich **2** Bard Zajac **3** Hiro Gosden **4** Dan Bikos **5** John Weaver **6** John Knaff **7** Mark DeMaria **8** Deb Molenar **9** John Forsythe **10** Chris Adams **11** Linn Barrett **12** Ken Eis **13** Joanne DiVico **14** Don Reinke **15** Marilyn Watson **16** Julie DeMuth **17** Kristi Gebhart **18** Holli Knutson **19** Bernie Connell **20** Korrie Klier **21** Mary McInnis **22** Mike Hiatt **23** Kelly Dean **24** Joe Gentile **25** Karll Renken **26** Doug Fox **27** Mohammed Ghemires **28** Dale Reinke **29** Adam Kankiewicz **30** Duane Whitcomb **31** Ray Watts **32** Andy Jones **33** Tom Vonder Haar **34** Brett Schichtel **35** Garrett Campbell **36** Tom Greenwald **37** Ben Ruston **38** Rob Fleishauer **39** Richard Austin **40** Brian McNoldy **41** Loretta Wilson **42** Ray Zehr **43** Don Hillger **44** Rodger Ames **45** Kathy Fryer **46** Dave Cismoski **47** Vince Larsen **48** Lance Noble

Boulder Group:

1 Cliff Matsumoto **2** Yelena Pichugina **3** Joanne Edwards **4** Maureen Murray **5** Julie Schenk **6** Mike Turpin **7** Frank Tower **8** Jim Frimel **9** Ning Wang **10** Sher Wagoner **11** Ali Zimmerman **12** Renate Brummer **13** Jacques Middlecoff **14** Ron Kahn **15** Sean Madine **16** Rob Newsom **17** Bob Lipschutz **18** Georgeanne Beck **19** Brian Jamison **20** Brent Shaw **21** Randy Colander **22** Ravi Bansal **23** Chungu Lu **24** Adrian Marroquin **25** Dave Salisbury **26** Yunfu Xie **27** Jim Fluke **28** Travis Andersen

Keeping Pace with Technological Advancement is Key to CIRA's Success

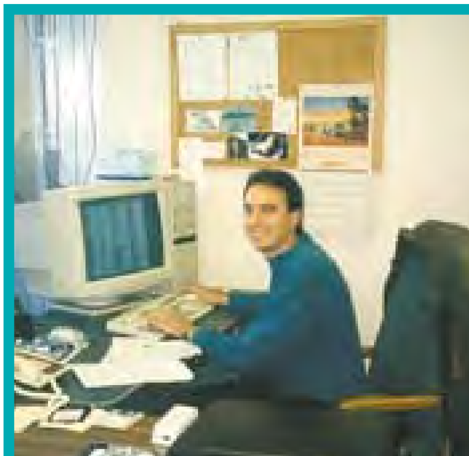


Michael Hiatt, Research Infrastructure Group Manager

In the last year, CIRA has implemented three significant infrastructure technologies to enhance automated system capabilities within the office. These include: the addition of a faster network, an improved operating system, and a new archive media. All three modifications have quickly proven their worth, and ultimately attest to the value of cutting-edge technology in support of CIRA's research mission.

Among some of the changes made was the replacement of aging network hubs with new 3Com network switches. These switches work more efficiently as they route network packets to specific destinations rather than broadcasting out to the entire system each time. Also, more fiber optic cables were installed to accommodate faster bandwidth. In fact, the impact was immediate and dramatic: bandwidth increased tenfold. As for the operating system at CIRA, Microsoft Windows 2000 replaced Windows NT 4.0 and has proven to be both more reliable and efficient. Windows 2000 provides support for more hardware, dynamically configures based on the hardware it detects, and continues to handle the full gamut of Windows-based software programs already familiar to most PC users. Moreover, Windows 2000 includes a new network model that provides improved group connectivity. Clearly, the better researchers, support staff, and management are able to communicate and share information, the better. Finally, Digital Linear Tape (DLT) has replaced 8mm tape for CIRA's central archive. This media is significantly faster and yet more reliable thanks in part to its non-helical scan design. Each tape can store roughly eight times as much data as before, thus resulting in easier data retrieval.

Dishing it up: CIRA staff assembling a satellite dish.



Infrastructure commander Mike Hiatt at the helm.

Looking ahead, future infrastructure improvements will include faster computers and networking, and larger, faster storage. Microprocessors of 1GHz will be installed in the coming year and it is anticipated that they will double current performance. As is typical of evolving technologies, expectations continue to grow more and more grand. For example, most experts agree that microprocessors will break the 2GHz barrier in the next two to three years, and that dual and quad microprocessor configurations will become the standard. CIRA's network model and performance is one of the most important infrastructure technologies to improve data processing and general research. Therefore, CIRA is planning to deploy 1GB/s network connectivity to individual computers and improved switches and routers within the next three to five years. Due to the large size of meteorological data sets, larger and faster data storage mediums will also be put into service. Disk storage of 1TB in individual research systems is expected at CIRA within three years. Optical storage such as CDR and DVD will also continue to play an important role in data distribution.

Satellite fantastic – proud CIRA staff at the dish farm.

ISCCP 1983-2000 and Beyond

G. Garrett Campbell, Research Associate

Under the auspices of NOAA, CIRA has had a long-running commitment to participate in the International Satellite Cloud Climatology Project (ISCCP). The primary goal of ISCCP is to advance our understanding of the Earth's climate and to validate the general circulation models that are so critical to weather forecasters and climate modelers.

CIRA and others began planning for this project in 1979, and the first data collected at CIRA for ISCCP came from the GOES-6 satellite in July 1983. CIRA's principle task in this endeavor has been to prepare calibrated counts for input into the ISCCP Global Processing Center cloud analysis algorithm. As the project has evolved, we have continued to collect data including GOES-6, 7, 8, 9 and 10, Meteosat 3, and INSAT. Figure 1 illustrates how the ISCCP data is used. This is a sample monthly average cloud amount developed from ISCCP analysis.

Hundreds of scientific papers have been written using the global cloud climatology and has consequently increased our knowledge about the impact of clouds on weather (or climate). To illustrate some sample ISCCP data, Figure 2 shows the time variation of the mean cloudiness over Colorado for an 11-year period. The remaining years from 1994 to the present are still being processed by the Global Processing Center. While there are certainly areas of the world which exhibit more dramatic seasonal and inter-annual variations, this chart shows what conditions we have here in Colorado.

Plans are currently in place to continue ISCCP until 2003. ISCCP at CIRA has been a cooperative effort among the principle investigators, the support staff, and the students. We would like to thank the many CIRA employees and students who have worked on the project overseen by G. Garrett Campbell, Kelly R. Dean, and Thomas H. Vonder Haar.

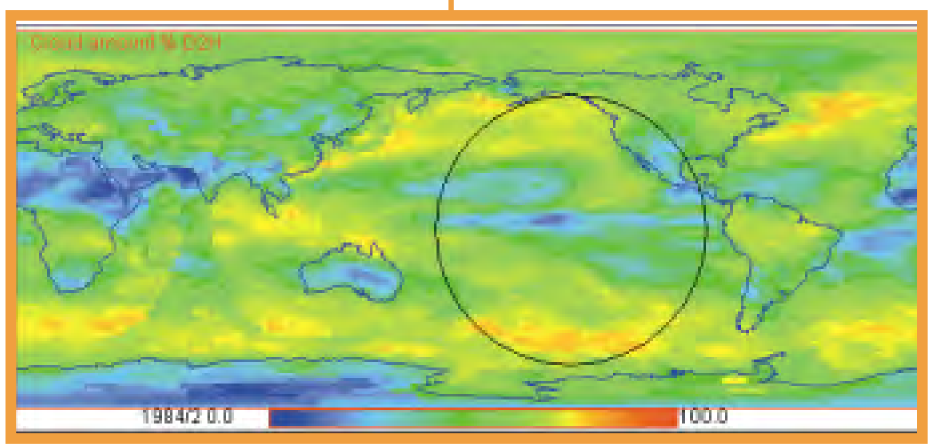


Fig. 1. ISCCP Cloudiness for February 1984. The circled region contains data from GOES-6 collected at CIRA.

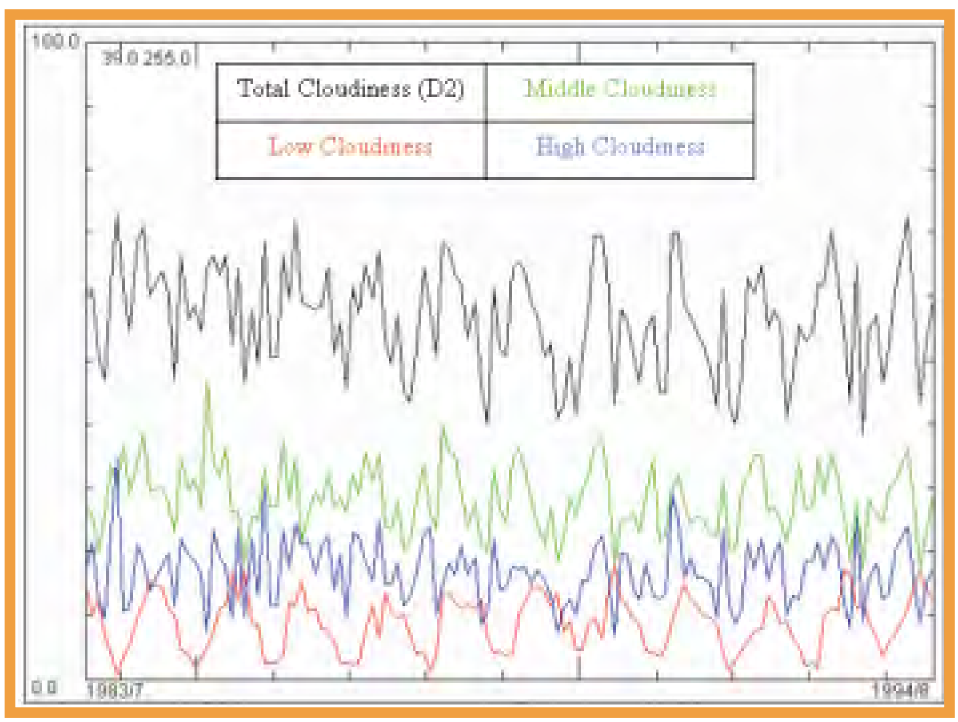
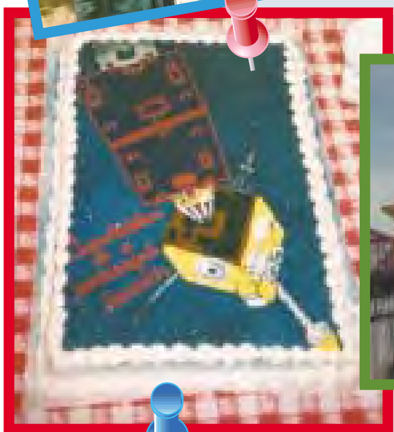


Fig. 2. Percentage of cloudiness for different cloud types over Colorado from 1983 to 1994.





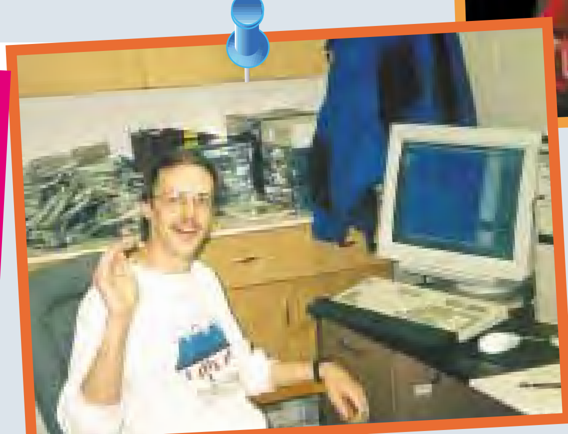




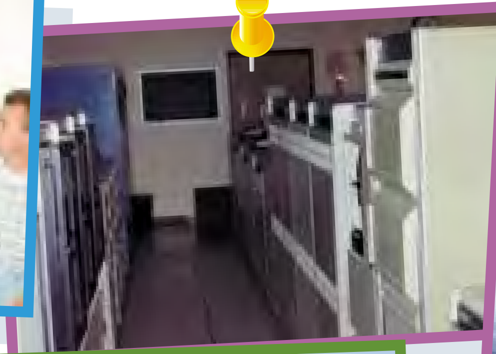
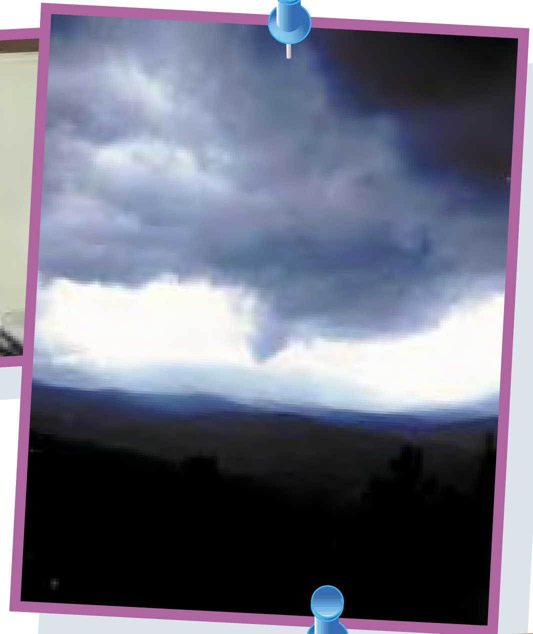
A Visual Souvenir

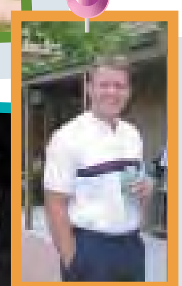


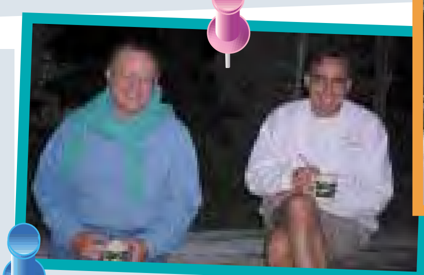
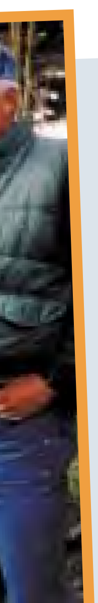
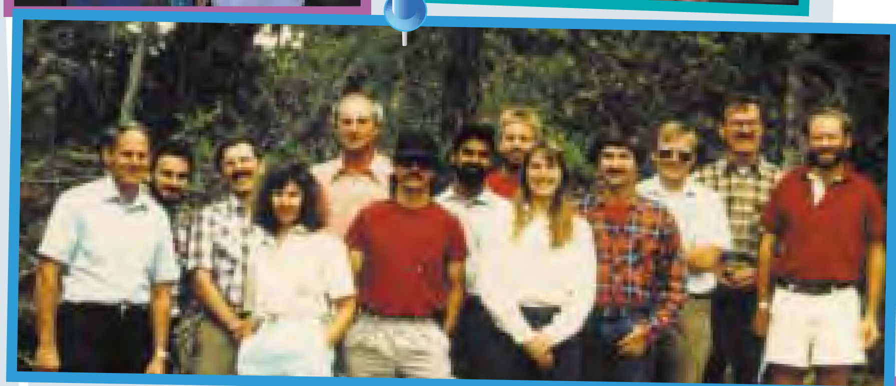
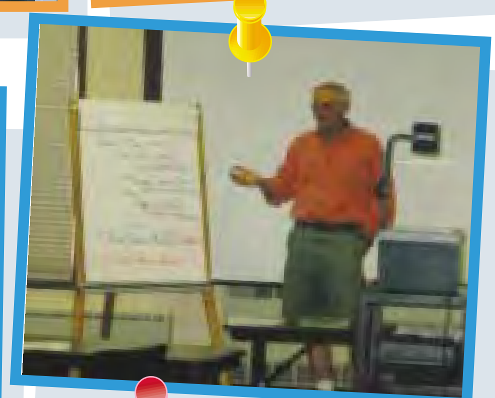







The RAMM Team at 20 and Looking to the Future

Don Hillger, NOAA/NESDIS/RAMM Meteorologist

How it began

In 1980, Colorado State University and NESDIS (NESS at that time) entered into a joint development effort for the use of meteorological satellite data for research and environmental applications. With the PROFS[1] activity in its genesis at the Environmental Research Laboratory in Boulder, it was recognized within NESDIS that a satellite focus in regional and mesoscale meteorology was needed in the Front Range area. In addition, there was a recognized need within NOAA to increase that component of research activities carried out jointly with academic institutions, thereby strengthening and broadening that interface. To help address those needs, NESDIS established the Regional and Mesoscale Meteorology (RAMM) Branch (now the RAMM Team) at CSU in the fall of 1980.

The RAMM Team began with five NESDIS employees moving from Washington, D.C. to Fort Collins, CO: Dr. James Purdom as Team Leader, Robert Green, Roger Phillips, John Weaver, and Dr. Ray Zehr. In 1997, Dr. Purdom accepted the position as director of the NESIDS Office of Research and Applications in Washington, D.C. Dr. Mark DeMaria took the position as RAMM Team Leader in 1998. Of the original members, Robert Green accepted another position in the late 1980s and Roger Phillips retired just this year. The Team has taken on two new NESDIS employees over the years, so the federal contingent remains at five. The Team has worked (and continues to work) closely with numerous CIRA research associates assigned to RAMM Team projects, with an effective Team of about 12 full-time research and support staff. We also help guide department of atmospheric science graduate students working on the M.S. and Ph.D. programs.

Past and Current Activities

The scope of activity at RAMM has expanded considerably over time. The RAMM Team has supported and participated in several meteorological field experiments. RAMM Team personnel have been (and are) co-investigators with CIRA scientists on grants from NOAA, NSF, and NASA. RAMM Team members are recognized both nationally and internationally, with invited international participation in conferences, workshops, and planning groups. Published results of Team members' research appear in professional journals, books, and conference reprint volumes.

Areas of meteorological investigation have expanded in scope since the Team's early days. From its inception, the RAMM Team has actively engaged in research at CIRA focused on utilizing satellite data in conjunction with other state-of-the-art data sets to better understand the development and evolution of convection and severe weather. A number of important findings have resulted from that research. Initial investigations focused on understanding and nowcasting convection and severe weather. The Team's research focus has since broadened to include tropical storms and mesoscale modeling of the atmosphere. Results from these new areas of investigation have proven fruitful.

The research success of the RAMM Team in conjunction with CIRA has resulted in augmentations to the CSU satellite data handling system, as well as additions to the image display systems within the CIRA facility. Funding from NOAA has allowed the RAMM Team to innovate in the development of satellite products and services from GOES[2] data. With the launch of GOES-8 in 1994 (Menzel and Purdom, 1994) a major focus of the RAMM Team has been on the development and improvement of applications of satellite data to many aspects of weather analysis and forecasting. These efforts continue as each succeeding GOES satellite is launched and the data are checked out, such as with the recent launch of GOES-11.

Another major effort at the RAMM Team has been the development of the RAMM Advanced Meteorological Satellite Demonstration and Interpretation System (RAMSDIS) in the 1990s (Molenar et al., 2000). RAMSDIS was developed to fill a gap between advancing digital satellite technology and the lack of capable display systems to make the data available to operational forecasters. RAMSDIS was developed to use McIDAS[3] software on PC-based systems and has been instrumental in providing GOES imagery to a wide audience of users. RAMSDIS is currently being replaced by AWIPS at National Weather Service offices, but as RAMSDIS evolves it still has an important role in the satellite research community. RAMSDIS is also finding an operational home in numerous developing nations where technology advancements are sorely needed, such as in Central and South America and Africa thru the RMTC[4] pro-

[1] PROFS = Prototype Regional Observing and Forecasting System
[2] GOES = Geostationary Operational Environmental Satellite
[3] McIDAS = Man Computer Interactive Data Analysis System
[4] RMTC = Regional Meteorological Training Center
[5] COMET = Cooperative Program for Operational Meteorology, Education, and Training
[6] VISIT = Virtual Institute for Satellite Integration Training

Improved CSU Satellite Data Handling System
Weather Analysis and Forecasting Applications
RAMSDIS
RAMM TEAM
NOAA
ACHIEVEMENTS
RAMSDIS Online (ROL)
Integrating Satellite Data and other Observations
Training NWS Meteorologists

gram (Purdom 1997).

While RAMSDIS was developed to provide a low-cost method for getting real-time digital satellite data into NWS offices, RAMSDIS OnLine (ROL) was constructed in 1998 with the idea of putting RAMSDIS and some of its capabilities on the World Wide Web. ROL allows for a much larger audience to view GOES images and products. Currently an average of 400 users per day access various versions of ROL for the opportunity to view animated real-time GOES data.

The RAMM Team has always been involved in training meteorologists on the use of satellite data. To facilitate this training, the Team has developed learning modules on the use of GOES imagery that are available on the Web. Also, a virtual laboratory accessible through the Internet allows researchers at other institutions to use digital satellite data collected at CIRA and collaborate with our researchers on particular weather events. The RAMM Team is actively involved in training with routine participation in both national and international training programs including the COMET[5] Satellite Meteorology series. As an outgrowth of these activities, the VISIT[6] program was developed as a means for regular training of NWS and other satellite data users.

The Future

The RAMM Team has been an important part of CIRA since its inception in 1980. The RAMM Team's focus is to develop new applications of meteorological satellite data to further the science of forecasting severe and/or convective weather events. Other areas of high priority research include: 1) The innovative use of computer technology in assimilating and utilizing satellite observations (i.e., radar, wind profiler, numerical model and other meteorological information) to more rapidly assess the state of the mesoscale environment; 2) Developing tropical cyclone forecasting techniques for determining formation, intensity, structure, and track; 3) Contributing to the evolution of satellite sensor technology; and 4) Providing training to National Weather Service and other forecasters in the application of satellite data to all elements of weather analysis.

Current information on CIRA's RAMM Team activities may be found on the Web at: http://www.cira.colostate.edu/RAMM/OVERVIEW.HTM

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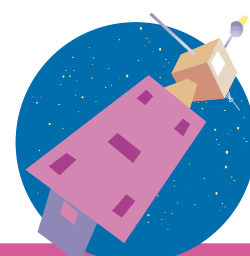
RAMSDIS Contributions to NOAA Satellite Data Utilization



Debra A. Molenar[1], Kevin J. Schrab[2], and James F. W. Purdom[3]

[1] NOAA/NESDIS/RAMM Meteorologist Regional and Mesoscale Meteorology Team, National Environmental Satellite Data and Information Service, NOAA, Ft. Collins, Colorado.

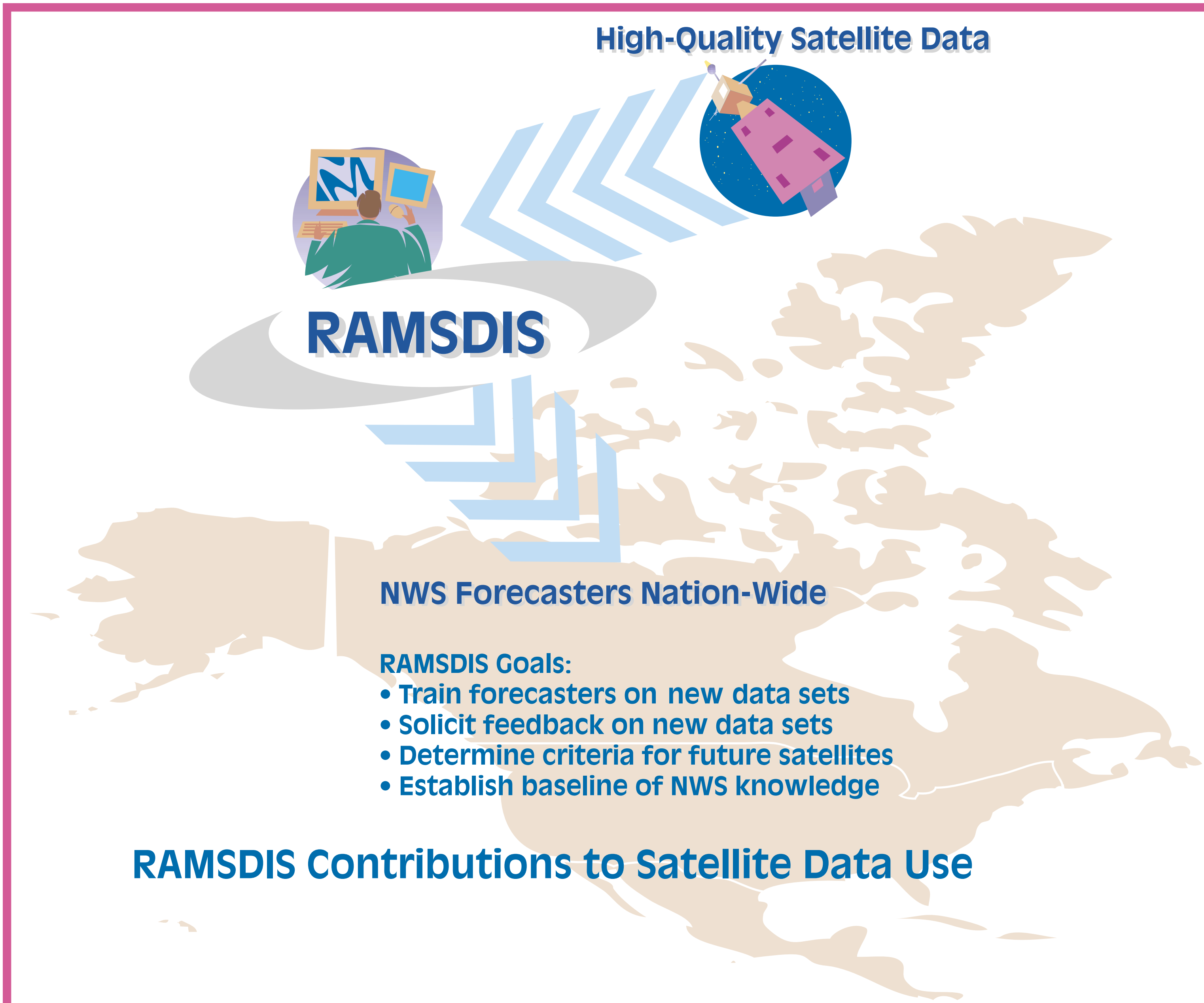
[2] NWS Meteorologist.Western Region Headquarters, National Weather Service, NOAA, Salt Lake City, Utah

[3] Director of NOAA/NESDIS/ORA. Office of Research and Applications, National Environmental Satellite Data and Information Service, NOAA, Camp Springs, Maryland

The following is an excerpt from an article published in the May 2000 Bulletin of the American Meteorological Society.

On 13 April 1994, the launch of the Geostationary Operational Environmental Satellite (GOES-I) introduced the first in a series of the National Ocean and Atmospheric Administration (NOAA) next generation geostationary weather satellites. Upon reaching geostationary orbit, GOES-I was renamed GOES-8. The new GOES satellites utilize a new three-axis stabilized spacecraft design, an improved multispectral imager, an advanced sounder, and a new ground data processing and distribution system. The GOES-I/M system, one of the major components of NOAA's National Weather Service (NWS) Modernization Program, offers significant advancements in geostationary environmental satellite capabilities, and with those advancements come education and training needs.

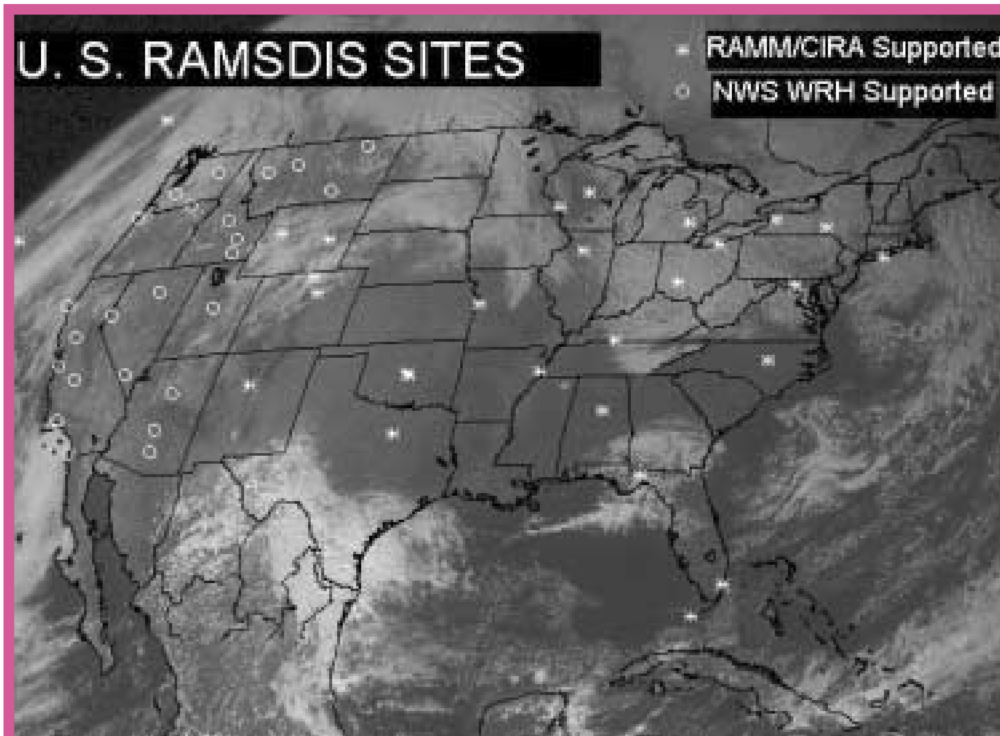
One of the primary responsibilities of the NOAA National Environmental Satellite Data and Information Service (NESDIS) Regional and Mesoscale Meteorology (RAMM) Team at CIRA is research, development, and evaluation of products to utilize all the capabilities of NOAA's advanced weather satellites and the transfer of those products to the operational community. The Team was tasked with GOES-I product evaluation and development prior to the launch of the



RAMSDIS Contributions to Satellite Data Use

GOES-I spacecraft. It soon became clear that there was no existing technology to get the new satellite data to field users, primarily NWS forecasters, for such an evaluation. NWS Modernization plans called for data dissemination via NOAA-PORT and data processing and display capability via the Advanced Weather and Information System (AWIPS). At the inception of this project in May 1993, installation of NOAAPORT and of AWIPS workstations was still many years away. Therefore, the new satellite data, a costly component of modernization, could not be fully utilized by the NWS. In response to this challenge, the RAMM/CIRA Team developed the RAMM Advanced Meteorological Satellite Demonstration and Interpretation System (RAMSDIS) as part of an effort to get high-quality digital satellite data to NWS field forecasters prior to the deployment of the satellite component of the NWS Modernization Program.

The RAMSDIS project was innovative for many reasons. Project goals required a system that was powerful, easy to use, quickly deployable, reliable, and low cost. No existing system could meet all of these criteria. As a unique solution, several advances were developed for existing technology. High-resolution display software, automated data ingest and display capabilities, advanced data analysis routines, and an easy to use menu system were developed at CIRA to supplement the satellite data dissemination and analysis capabilities of the Man-Computer Interactive Data Access System (McIDAS)-OS/2 created at the University of Wisconsin Space Science and Engineering Center (UW/SSEC). These advances created a low cost, high-powered PC-based satellite data ingest, display, and analysis workstation that did not require extensive forecaster training. Data was served to Forecast Offices (FOs) automatically via the Internet from a NESDIS server in Camp Springs, MD. The creative use of new and existing technology greatly reduced system design and implementation costs, and provided reliability not available with new, untested systems. The first workstations were ready for deployment within 6 months of project start, and arrived in FOs in October 1993. Each system was pre-configured at CIRA for



site-specific data and network requirements, then shipped to the FO. System installation at each FO consisted of assembling computer components and plugging the system into a network line.

The RAMSDIS project has always been non-operational, aimed at increasing digital satellite data utilization, and has received wide acceptance by field forecasters and research specialists alike. At deployment peak in June 1999, workstations were used in over 60 sites (approximately half of the NWS FOs) throughout the U.S. However, even those numbers do not describe the true impact of the RAMSDIS project because many RAMSDIS sites posted the RAMSDIS data on servers for access by other Weather and River FOs. Therefore, many RAMSDIS sites became distribution hubs for real-time digital satellite data to FOs throughout the U.S. Moreover, when AWIPS deployment began in 1997, FOs receiving AWIPS sent their RAMSDIS workstations to offices that did not have access to digital satellite data, further increasing the early field exposure. In addition to use in routine forecasting and training, RAMSDIS has also supported field experiments and joint research projects with the NWS and other NOAA laboratories. These projects include the NWS GOES Assessment, the 1996 Summer Olympics in Atlanta, GA, the Lake Effect Snow Study, the Lubbock Dryline Study, and the Verification of the Origins of Rotation in Tornadoes Experiment. Before RAMSDIS deployment during the Lake Effect Snow Study, satellite data was ranked last (out of 7) in utility for short-range forecasting. After RAMSDIS deployment, satellite data was ranked second to radar and remained that way throughout the study.

The goals of the RAMSDIS project were to: 1) familiarize forecasters with use of the new data set to lessen the modernization learning curve; 2) solicit feedback on the data set utility and on data set products that would be useful in the modernized FO; 3) determine criteria for future satellite sensor systems (which must be developed years in advance of actual spacecraft deployment); and 4) establish a baseline of NWS field knowledge regarding multi-spectral digital geostationary satellite imagery to determine future training requirements. These goals have been achieved and have provided better field training, improved forecasts, new products and services, and aided the development of future GOES operational schedules.

The RAMM/CIRA Team currently supports RAMSDIS workstations in 10 NOAA labs and over 35 field sites, including FOs in Alaska and Hawaii. In addition, the RAMM Team uses over 20 in-house RAMSDIS to support routine satellite data ingest and ongoing research. As NWS utilization of RAMSDIS decreases, offshoots of RAMSDIS are being developed to support additional projects. These projects include expanded support for the existing World Meteorological Organization (WMO) Regional Meteorological Training Centers (RMTCs) in Central America to provide improved forecasting capabilities in the aftermath of Hurricane Mitch; deployment to Brazil for use in fire detection; and increased use within global WMO offices to support standardized research and training tool development. There has also been increased development for capabilities within existing NOAA laboratories, including upgraded systems to monitor satellite signal quality and navigation and to support tropical research and reconnaissance flight operations during hurricane season. The RAMM Team has completed development of a version of RAMSDIS that utilizes McIDAS-X running on Windows NT and plans to test the Linux platform also. However, it is anticipated that the existing OS/2 workstations will remain in use as long as they are functional.

In appreciation

The RAMSDIS project was successful because of the hard work of a number of individuals from various organizations. Many people at CIRA, including visiting scientist Yang Jun of the Satellite Meteorology Center in Beijing, China, created RAMSDIS from the basic McIDAS-OS2 software originated by UW/SSEC. The dedication and technical skills of Hiro Gosden and Todd Smith, who provide development and field support, have been the backbone of the project. Dave Watson is responsible for the development and maintenance of the Internet version of RAMSDIS (RAMSDIS Online), an innovative training tool that has potential to reach a very large audience for many years to come. Dr. Bernadette Connell, Dr. John Knaff, and Dr. Ray Zehr continue to develop new applications for RMTC and Tropical RAMSDIS; and Dr. Donald Hillger provides research products and image quality support to NESDIS Satellite Operations and Control Center. The NESDIS Satellite Services Division continues to provide data and troubleshooting support for the NESDIS server. Tom Whittaker and John Benson of UW/SSEC have made invaluable contributions to the project through their software innovations, consultations, and development efforts. Dr. Paul Menzel of NOAA/NESDIS/CIMSS and Andy Edman of NWS World Regional HQ's (WRH) provided support for this project at many critical points.

Center for Geosciences/Atmospheric Research (CG/AR): 12 Years of DOD-Sponsored Research

Ken Eis, Deputy Director

The Center for Geosciences/Atmospheric Research (CG/AR) is a multi-disciplinary activity within CIRA that has a long history of providing research to the Department of Defense (DOD). CG/AR was created to harness the resources of several CSU academic departments and to provide research on militarily relevant topics.

Since the mid-1980s, DOD research and development budgets and meteorological staff have been shrinking steadily. Despite an ever-growing need for research on technical issues, the atmospheric science laboratories at DOD lost substantial portions of their budgets and manpower. In response to the shortfall, the Army conducted a peer-reviewed grant competition in 1986. This initiative, called the Army University Research Initiative (URI), was designed to fund broad areas of inquiry relevant to the needs of the military. CIRA and CSU won the URI grant that year, and CG/AR was born.

CIRA has hosted three phases of DOD-sponsored research since the initial Phase I grant in 1986, with one break in 1993-1994. The second and third phases of the project were part of a DOD-level grant that broadened the scope of the Center's research to include Navy and Air Force issues. As of the time of publication, this endeavor has supported 89 graduate students, and produced 366 scientific publications. A synopsis of the first two phases of the project is provided in the table at right.

Areas of Research:

Phase I (September 1986 - June 1992)

- Satellite, Radar, and Lidar Remote Sensing
- Atmospheric Modeling
- Hydrologic Modeling
- Boundary Layer Studies
- Climatic Geomorphology
- Information Extraction and Visualization

Phase II (October 1994 - July 1998)

- Fog and Haze Observations
- Fog Forecasting
- Cloud Drift Winds
- Detection of Total Cloud Liquid Water Over Land
- Coupled Hydrologic Modeling with Satellite Remote Sensing and Atmospheric Mesoscale Models.
- High Spectral Resolution Lidar for Assessing Aerosol, Wind and Temperature Variability
- Measurement and Analysis of Complex Layered Cloud Systems
- Radar (NEXRAD/CSU-CHILL) Algorithm Studies
- Neural Network Approach to Cloud Data Analysis

Phase III (underway since October 1998) focuses on these topics outlined below:

1. ***Hydrometeorology*** – This theme focuses on precipitation amounts and rates, soil moisture, stream and overland flows, as well as improved detection and forecasting of water in the atmosphere. These focus areas will directly improve our understanding of agricultural meteorology, flash flooding, and river crossing and trafficability problems that are of direct concern to Army maneuver units.

2. ***Cloud Structure, Dynamics, and Climatology*** – This theme focuses on clouds and their structure, radiative properties, phase (ice, water or mixed), growth and decay, and their extent in the vertical (cloud tops, bases and layers) and horizontal (cover and motion). CG/AR's research has placed particular emphasis on the complex middle cloud layers that tend to be non-precipitating in nature, cloud layers that have proven most significant to air operations in Desert Storm and the recent Kosovo/Serbian operations. These clouds, despite their benign weather consequences, often obscure the air-to-ground view for intelligence gathering, strike missions, and battle damage assessments.

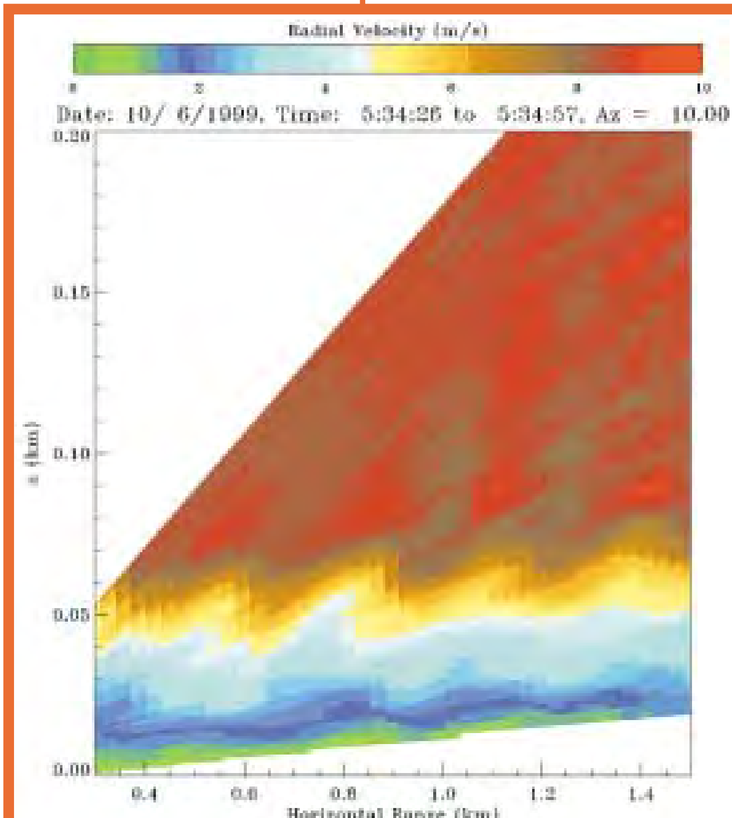
3. ***Data Assimilation and Data Fusion***– This theme is pertinent to both civilian and military weather forecast operations. CG/AR is working on the latest and most advanced way of assimilating measurements (for example, from satellites, surface instruments, and radar) into forecast models that may eventually improve weather forecasts. It's called adjoint modeling. It provides an optimal way of adjusting the forecast model during the assimilation process. It also exploits the full information content of the measurements and can account for measurement bias errors. This approach to data assimilation is particularly useful to forecasters in areas where conventional surface observations are unavailable.

4. ***Chemistry, Aerosols and Visibility***– This theme will allow researchers to use new satellite information to fight the oldest nemeses of military planners, pilots, tank drivers, and ship captains: fog, smoke, and haze. CG/AR is exploring ways to remotely measure the thickness (optical depth) of smoke and haze, which is valuable information to satellite and high-altitude reconnaissance systems. While not possible with traditional satellite sensors, measuring the chemical composition of these particulates will one day be possible with the genesis of spacecraft such as Terra (NASA's first Earth Observing System satellite) and the hyperspectral imagers soon to be incorporated on the next generation of geostationary weather satellites.

5. ***Remote Sensing of Battlespace Parameters –*** This theme encompasses several different technologies that will be exploited by military (and civilian) operations using newly developed remote sensing technologies such as LIDAR and multi-channel high-resolution satellite data. One of the major areas being explored concerns phenomena that develop in the nocturnal boundary layer, such as low-level winds and intermittent turbulence caused by viscosity breakdowns and other non-linear effects. Without a full understanding of these phenomena, our ability to predict chemical weapons dispersion patterns is compromised. This was clearly illustrated in Kamasia, Iraq at the end of Desert Storm when an Iraqi munitions depot was destroyed by U.S. troops. Later it was learned that some of the munitions were chemical shells and missile warheads. Due to a lack of knowledge about the processes that transported the chemicals during the night, a subsequent low-level wind and toxic chemical dispersion analysis failed to correctly identify which troops had been exposed.

Photo by Senior Airman Diane S. Robinson, USAF

Source of both photos was: http://www.defenselink.mil



Scanning Doppler LIDAR snapshot taken at night during CASES-99 showing overturning atmospheric waves.

What's Driving the Research?

The U.S. military has experienced significant changes in both its mission and in technology in the last two decades. These include:

1. Change in the geo-political landscape: the Cold War is over. The U.S. military is now defending American interests all over the world and is engaged in peacekeeping activities that utilize a major portion of its active force structure. CG/AR is producing a global-scale cloud database at an unprecedented resolution (5-km and 1 hour). This database could be used to support global simulations, training, and as a forecasting aid.

2. Change in the threat: the U.S. military is no longer concerned about fighting an all-out nuclear war or a multi-theater war against a highly trained and well-equipped adversary. We now face terrorists with chemical and biological weapons and small countries with the increasing technical ability to inflict mass destruction through purchased or stolen technologies. CG/AR is busy supporting this area of concern with improved toxic dispersion research, data fusion technology and observational improvements in low-level winds.

3. Change in the technology: Stealth aircraft, ships, and land vehicles, in concert with precision-guided munitions, have revolutionized the point of attack for American forces. Cloud base heights and visibility from aircraft to ground are among the key issues that CG/AR is working on in this area.

Recent Outcomes

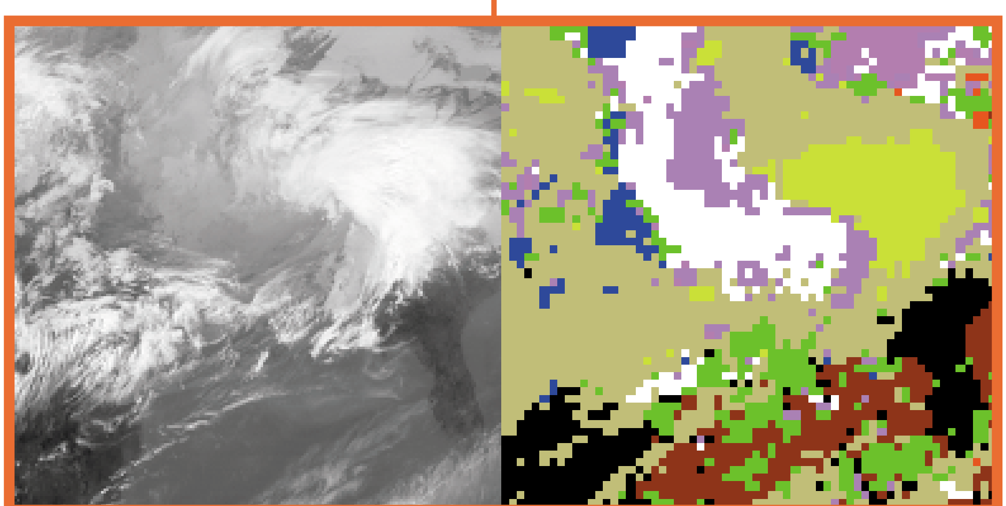
Two major field programs, CLEX-5 (Complex Cloud Layer Experiment #5) and CASES-99 (Cooperative Atmosphere Surface Exchange Study), were conducted in the fall of 1999. CLEX-5 collected mid-level cloud information associated with research theme #2. CG/AR funded a newly developed Environmental Technical Laboratory scanning LIDAR deployment to the CASES-99 operations area in central Kansas explicitly to measure the 3-dimensional aspects of the nighttime turbulence for research theme #5.

Although the research has just begun and results are typically loaded at the end of a project's life, CG/AR has already completed a variety of technology transfer activities to the DOD. These include:

- Production of a CHANCES-97 database product. This cloud database is a global 5-km, hourly data set for the 1997 El Niño year. In conjunction with the CHANCES-95 data set, it will allow military planners and acquisition managers to use cloud cover information of higher fidelity to aid in making a variety of decisions. The CHANCES-95 data set was recently moved to CD-ROM, which will significantly expand the potential number of users of this data set within the DOD.
- Transferal of Cloud Drift Winds (CDW) analysis to the Air Force Weather Agency (AFWA). CDW analysis is a stereo technique that exploits two weather satellites to measure wind speed and direction by using clouds as atmospheric tracers. Unlike older techniques that use single satellites and multiple image sequences, this technique also estimates cloud top height. NOAA, the Navy, Air Force, and our NATO allies are all considering the implications of this method. Continued improvements in the technique, including an automated cloud feature identification scheme, are also quite close to implementation.
- A new satellite-based microwave-infrared method for measuring cloud liquid water over land was transferred to AFWA. Observations obtained from this method are anticipated to have their greatest impact in helping to identify icing conditions for aircraft.
- Creation of new weather products from Geostationary Operational Environmental Satellite (GOES) imager data. Civilian and military forecasters alike use these products as they are funneled back into NOAA's production system.
- Of particular interest to the DOD, is the development of techniques to measure haze and smoke from geostationary satellites. This near real-time capability will be transferred to AFWA soon for prototype testing. These products can be used to make corrections to high-flying aircraft and satellite reconnaissance systems in an effort to improve our understanding of the military, agricultural, and industrial activities undertaken by potential adversaries.
- A new cloud base analysis is being tested by the Air Force. CG/AR has developed an improved method for blending surface and satellite measurements to determine cloud bases and thickness. Information on cloud base height is critical to air safety and for ground-attack planning.
- A new neural network-based cloud typing method has been developed and is about to be transferred to the Army, Navy, and Air Force. Although neural networks have been used to type clouds before, this new method uses temporal adjustment (first time ever used in a neural network setting). This adjustment compensates for variations in cloud reflectance as the sun's illumination angle changes.
- An advanced method that retrieves profiles of atmospheric temperature and humidity from satellite microwave sounder data is being tested by the DOD. The method falls into the class of "optimal" methods, ultimately providing more accurate profiles for use in numerical weather forecasting. The greatest benefits will be realized in regions where conventional balloon soundings are not available (i.e., over a battlefield or the ocean).
- CG/AR staff is leading an effort to improve collaboration between the Army Integrated Weather Effects Decision Aid (IWEDA) and NOAA's Local Data Acquisition and Dissemination (LDAD) system. These two computer display systems both convert basic weather data into a decision assistance system. The Army IWEDA provides assistance to the battlefield commander by determining specific weather imports on friendly and enemy weapon systems. LDAD systems provide more generic support to emergency management in the civilian community as an adjunct to the NOAA NWS's Advanced Weather Interactive Processing System (AWIPS). This sharing of technologies offers improvement potential for both systems.

Final Thoughts and Outlook

The Center for Geosciences has been a positive contributor to this nation's understanding of the atmosphere. It has not only supplied peer-reviewed papers on a host of subjects, but also numerous tools and algorithms to the DOD that will improve their use of weather. The future holds further promise for breakthroughs as CG/AR is looking to incorporate cloud radar and hyper-spectral technologies anticipated in the next five years.



GOES-8 infrared image of North America (left) and corresponding cloud classification obtained from Neural Network analysis (right).

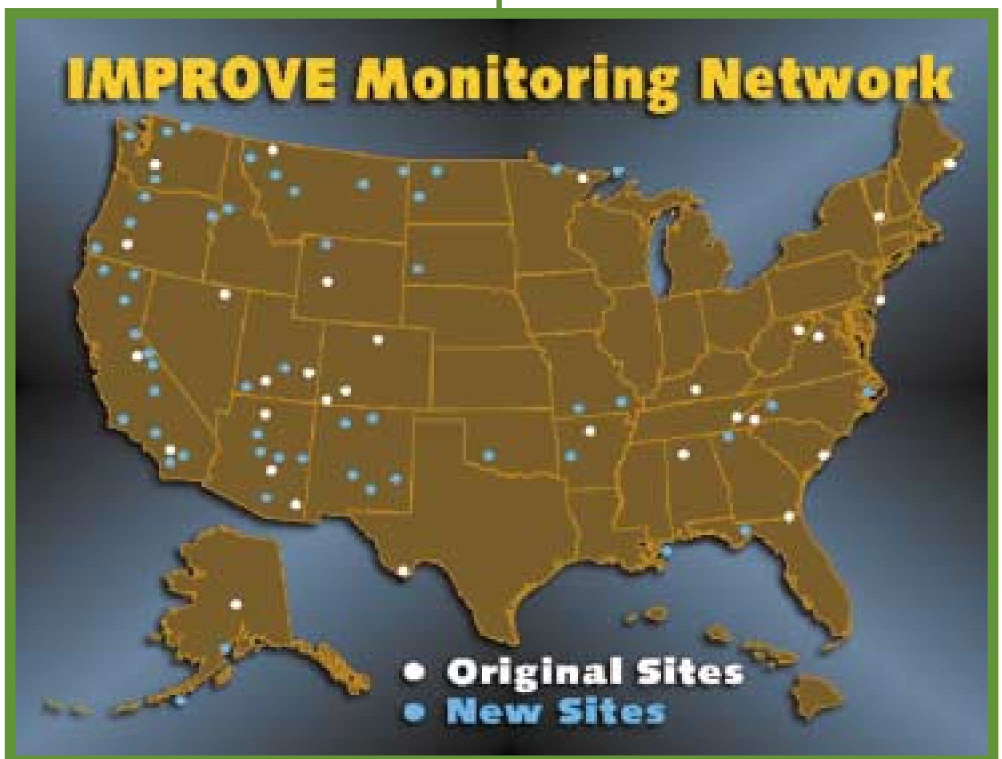
CIRA's Air Pollution Research: Past, Present and Future

Douglas G. Fox, Senior Scientist

Since the early 1980's, CIRA has supported the National Park Service (NPS) visibility research program directed by Dr. Bill Malm. Through the years, this group has been responsible for formulating and implementing the Clean Air Act mandate to land managers to protect the visual resources of such special federal areas as National Parks and Wilderness, so called Class I areas. The Clean Air Act in 1977, set as "... a national goal the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Federal Class I areas which impairment results from manmade air pollution."

Since the Act passed, the EPA has issued regulations to accomplish this goal; first, in 1980 addressing pollution that was "reasonably attributable" to a specific source, and most recently, in April 1999, addressing "regional haze." The regional haze regulations require states to plan to achieve "natural" visibility conditions within the next 60 years.

The NPS/CIRA research group under Malm's leadership has been instrumental in advancing the science and developing the methodologies that have enabled these regulations. Among their accomplishments is development of the appropriate metrics to use for characterizing visibility, determination of the most appropriate instruments to measure visibility for this application, and designing and implementing the national monitoring network for visibility. It is the national monitoring network, or IMPROVE, that represents the group's most important contribution. IMPROVE is supported by EPA, federal land managers, and states, and implemented through contracts with the University of California, Davis and Air Resources Specialists, Inc. as well as others. This network has developed from its initial form as primarily a research tool to its current existence supporting the EPA and the states in developing and tracking accomplishments under the regional haze regulations.



In the remainder of this article, we briefly introduce some details about the IMPROVE network, its results to date, and some of the scientific challenges that remain. Finally, we conclude with some comments about the future of this research activity at CIRA.

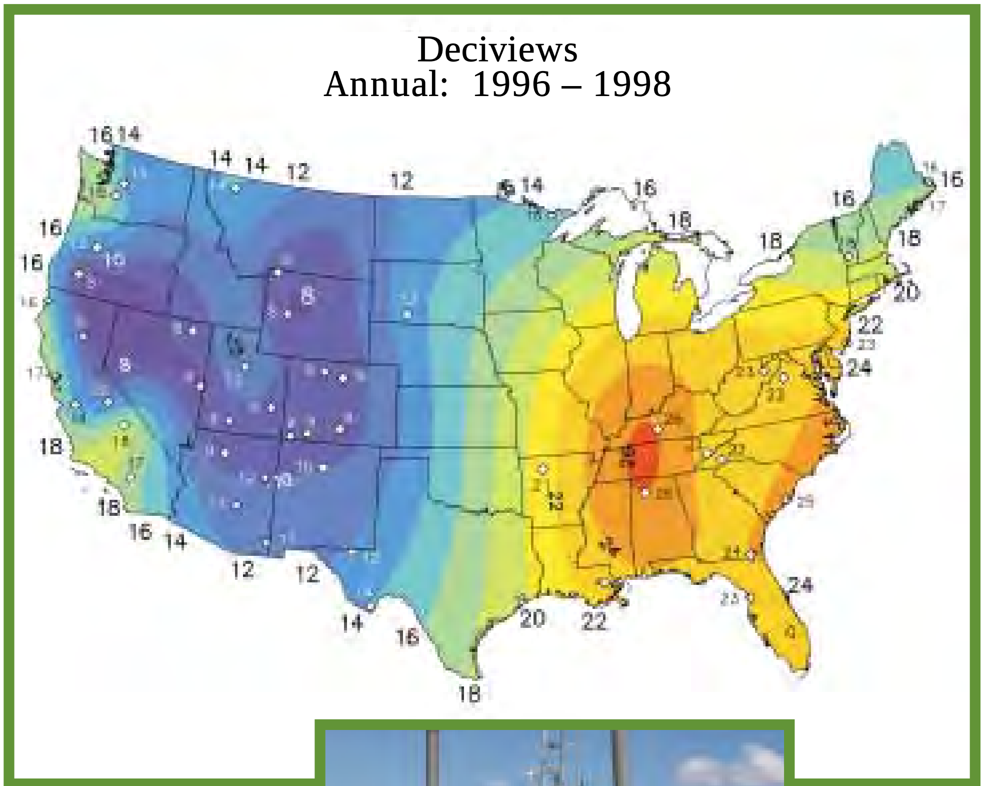
Current results from the IMPROVE network

IMPROVE is a network of 120 sites located to represent the Class I areas, National Parks and Wilderness identified in the Clean Air Act. It has been extended over the past year to about 70 sites which are used for the analysis reported in the latest IMPROVE report (Malm 2000a). The basic measurements at each site are particles that are smaller than 2.5 micrometers in diameter. These particles are collected on Teflon, nylon and quartz filter substrates so that they can be subjected to a variety of chemical analyses. That data then allows an approximation of the chemical nature of these particles. This chemical speciation has been essential in establishing the relationship between pollution sources and their final impact on visibility even after hundreds to thousands of kilometers of transport and both photochemical and aqueous phase transformations.

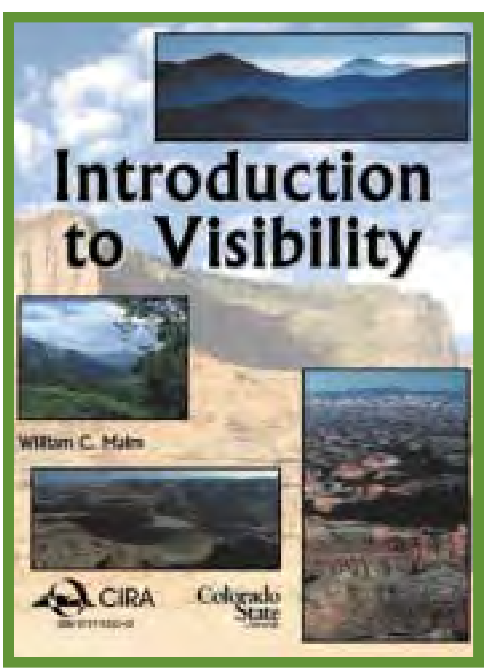
The latest results of the IMPROVE network are presented in terms of the annual average visibility in the United States, as measured in deciviews (see accompanying figure). Deciviews are analogous to decibels in acoustics, that is, they are proportional to the log of the extinction coefficient. Rayleigh scattering in an unpolluted atmosphere has a deciview value of zero. Each deciview value above zero represents a linear increment of perceptible pollution. Thus, the visibility in the eastern United States, with visibility on the order of 20 deciviews, is considerably more impacted than visibility in the western United States, where it is more on the order of 10 deciviews.

The EPA regional haze regulatory program requires a determination of what levels of visibility impairment are 'natural.' This is difficult to determine because there are a number of natural activities that contribute particles to the atmosphere (forest fires, volcanoes, dust). However, it is helpful to look at the chemical species that contribute to visibility degradation in order to identify linkages between these concentrations and sources of pollution. Sulfates are found to dominate the visibility degradation in the east, while nitrates dominate visibility degradation in the vicinity of southern California. Clearly, there is nothing natural about this distribution of visibility; it is caused by human activities, predominantly by coal-fired electric generation in the east and by automobiles in southern California.

Among the more interesting observa-



IMPROVE aerosol sampler



tions from the IMPROVE data is that of the contribution by organic carbon (results not shown). These observations suggest that organic carbon makes a significant contribution to visibility degradation. In particular, it makes an even more significant contribution to visibility impact on the 10% of the days that have the worst visibility in the western U.S.

Future directions for our research

There are a number of sources of the organic carbon aerosol measured by IMPROVE. Transportation sources, other sources of volatile organic compounds, VOC's, indeed all combustion of carbon containing fuels are included. Important to the National Parks and Wilderness, however, are vegetation fires. Forest, grassland, and agriculture burning, either as wildfire or within a management program, represents a source of carbon particulate that must be better understood.

We recently (Fox et al., 1999) suggested a list of research needs associated with smoke and visibility, they are largely repeated below:

- The attribution of smoke to PM2.5 and visibility degradation at points that are 100 km or more distant from a fire. While newly developed measurements of "markers" which allow attribution of elemental and organic carbon to wood smoke exist, they need to be tested in realistic field experiments.

- Instrumentation that has the capability to measure the mass of smoke emitted from various kinds of fire should be developed and tested in realistic field experiments.

- Assessing visibility impacts of smoke emission requires knowledge of the optical characteristics of smoke. The ability to accurately measure atmospheric absorption is essential for estimating the visibility effects of smoke. Smoke particle scattering albedos, extinction properties, particle size distributions, and microstructure (internal mixing characteristics), are all important for the accurate modeling of smoke optical properties. Instrumentation to estimate atmospheric absorption to an accuracy of 10% is needed.

- It is necessary to improve the capacity to simulate fire emissions and their effects on ambient aerosol concentrations. New measurement technologies combined with their use in field experiments will collect new data that can improve understanding of generation, transformation, and removal processes of fine particulates. However, to determine historical levels of smoke and to evaluate the effectiveness of air quality management programs, these new data will need to be incorporated into the next generation of air quality models. One prospect for doing this is through the use of EPA's newly available comprehensive atmospheric simulation system, Models3/CMAQ (Byun and Ching, 1999). Use of this system will allow improvement in both meteorological (transport and dispersion) and chemical transformation aspects of simulating smoke.

The NPS research group at CIRA will continue to study relationships between human-caused air pollution and its impact on visibility. The concentration on smoke and fire identified in this article is but one of a number of similar research issues that the group will pursue in the future. For example, considerable future attention will be directed toward understanding the hygrospic nature of aerosols as well the chemical and optical properties of 'course' particles (those between 2.5 and 10 micrometers in diameter).

Finally, over the past 20 years, the NPS group at CIRA has developed and presented a wide variety of educational and informational products. One popular example is the Introduction to Visibility, recently revised and re-released (Malm 2000b). In the future, the group is planning to make IMPROVE and other air quality data and analyses much more broadly available through an interactive web page. Web presentation and publication will become a norm for the group in the future.

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As a postscript to this edition of the CIRA newsletter, we would like to draw special attention to several upcoming events. To "officially" commemorate CIRA's 20th year, all CIRA employees have been invited to anniversary luncheons. The Fort Collins group has been invited to a special luncheon to be held at the Cottonwood Club, and the Boulder group will enjoy a special catered event to be held at the home of Associate Director, Cliff Matsumoto. Each gathering will be highlighted by a presentation to recognize the achievements of several individuals whose contributions have significantly impacted the Institute over the years. The next edition of our newsletter will feature these awards.

Finally, it must be said that compiling this exclusive edition of the CIRA newsletter was no small endeavor. In an effort to summarize the accomplishments of an organization as diverse and successful as ours, and to trace the history of two decades worth of research, a great deal of help was required from folks outside of the core newsletter staff. In addition to the thanks due those individuals who contributed articles, we would also like to send our appreciation to the following individuals: Holli Knutson, Linn Barrett, Joanne DiVico, John Knaff, Rob Newsom, Ian Wittmeyer, and Julie Winchester. Their involvement was crucial to the timely and accurate production of the newsletter, and we want to be certain they know how much we appreciate their help.

CIRA Mission

The Cooperative Institute for Research in the Atmosphere (CIRA), originally established under the Graduate School, was formed in 1980 by a Memorandum of Understanding between Colorado State University (CSU) and the National Oceanic and Atmospheric Administration (NOAA). In February 1994, the Institute changed affiliation from the Graduate School to the College of Engineering as part of a CSU reorganizational plan.

The purpose or mission of the Institute is to increase the effectiveness of atmospheric research of mutual interest to NOAA, the University, the State and the Nation. Objectives of the Institute are to provide a center for cooperation in specified research programs by scientists from Colorado, the Nation, and other countries, and to enhance the training of atmospheric scientists. Multidisciplinary research programs are given special emphasis, and all university and NOAA organizational elements are invited to participate in CIRA's atmospheric research programs. Participation by NOAA has been primarily through the Oceanic and Atmospheric Research (OAR) Laboratories and the National Environmental Satellite, Data, and Information Service (NESDIS). At the University, the Departments of Anthropology, Atmospheric Science, Biology, Civil Engineering, Computer Science, Earth Resources, Economics, Electrical Engineering, Environmental Health, Forest Sciences, Mathematics, Physics, Psychology, Range Science, Recreation Resources and Landscape Architecture, and Statistics are, or have been involved, in CIRA activities.

During the past fiscal year, the Institute's research has concentrated on global climate dynamics, local-area weather forecasting, cloud physics, the application of satellite observations to climate studies, regional and local numerical modeling of weather features, and the economic and social aspects of improved weather and climate knowledge and forecasting. The Institute and the National Park Service also have an ongoing cooperation in air quality and visibility research which involves scientists from numerous disciplines. CIRA is playing a major role in the NOAA-coordinated U.S. participation in the International Satellite Cloud Climatology Program (part of the World Climate Research Programme).

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